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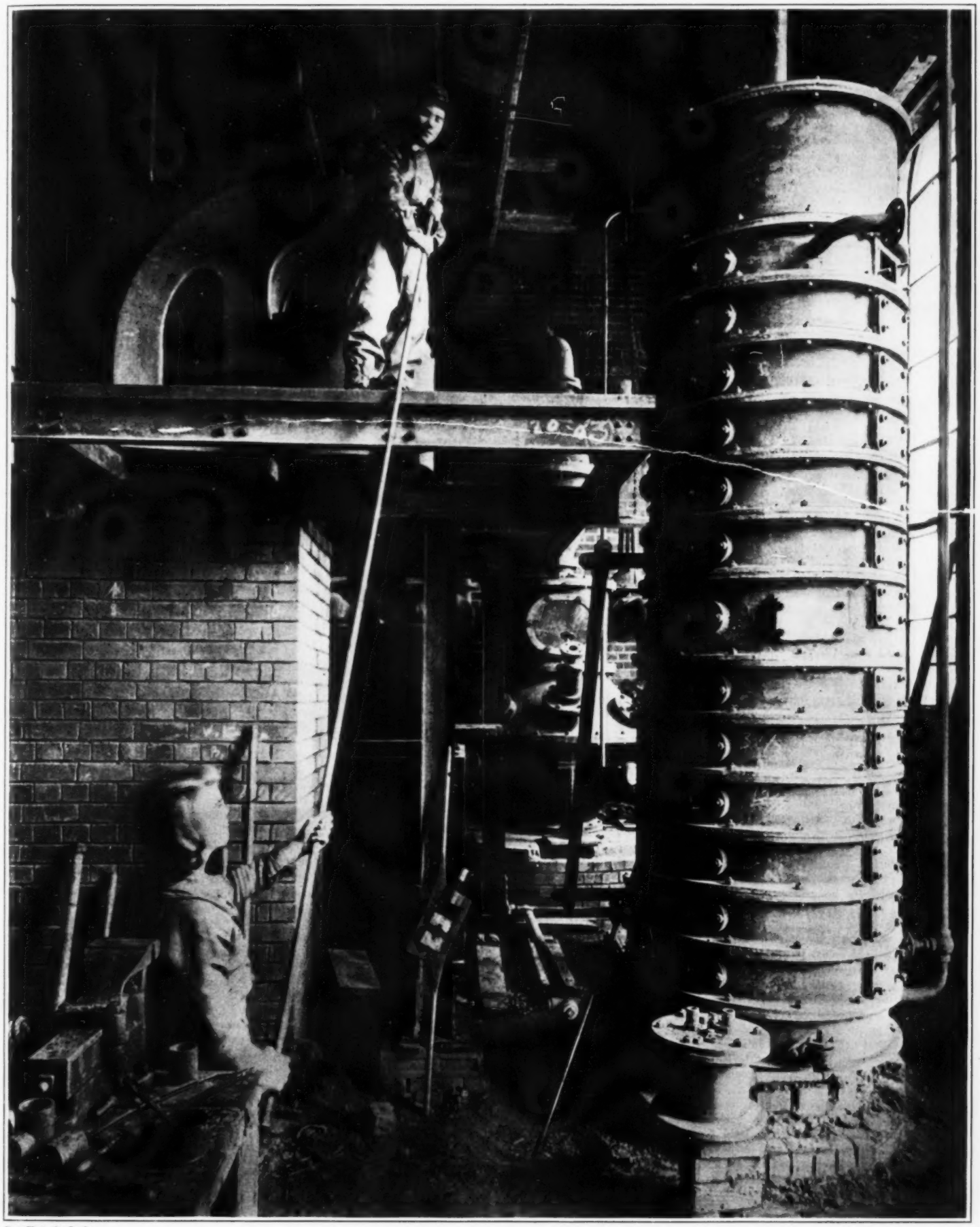


Press Illustrating Service

Women erecting and fitting heavy apparatus in a chemical factory [See page 56]

WOMEN IN TECHNICAL WORK

The Submarine*

Modern Development of an Old Invention

By Marley F. Hay, Member of Soc. N. A. and M. E.

THE outbreak of war in August, 1914, found the supreme naval power, Great Britain, in possession of the numerically strongest submarine fleet. It comprised about 90 vessels, ranging, with a few experimental exceptions, from 200 to 800 tons in displacement.

The submarine at that time was admittedly and manifestly the weapon of the weaker power, inasmuch as it was presumably a weapon preeminently of defense, and it was hardly deemed politic for secondary or lesser powers to entertain aggressive national policies. Moreover, the tremendous pecuniary burdens involved in the acquisition and maintenance of a fleet of capital ships reduced this policy of defense to a policy of necessity. So conclusively is this the case that certain of the smaller powers have conceded the principle that, militarily speaking, submarines should form the major part of their fleet, with only a certain number of destroyers and auxiliaries as supports.

While the principle has been fully recognized in theory, a subtle but powerful consideration has tended to prevent its full implementation in practice; namely, the service or personnel necessity for large ships. An exclusively submarine navy would provide no sea commands for officers who had passed their thirtieth or thirty-fifth year, so that large ships have been incorporated in the fleet if for no other purpose than to provide higher commands for older officers and to offer sufficient incentive for young men to enter the naval service, without which prospect the ranks of the Naval Academy would have been hopelessly depleted. This has constituted the principal motivation for large ships in certain concrete instances. During the nineteenth century, Great Britain has occupied the position of supreme naval power, hence all other powers have been comparatively and relatively in the position of navally weaker powers. The logical result of this status should have caused the British Admiralty to discourage early efforts to establish the practicability of the submarine, and that the situation was thus appreciated is evidenced by the fact that Robert Fulton, the American inventor of an early type of submarine, was offered substantial remuneration by the Admiralty for the entire suppression of his patents and ideas. This occurred a century ago, after his failure to obtain recognition in America and France.

In 1914 Great Britain's numerical superiority in submarines was probably attributable to a belief in the suitability of submarines for coast and harbor defense which had in fact been amply demonstrated by their success in the naval maneuvers of the preceding five years. The utilization of submarines for coast and harbor defense naturally released a certain part of their fleet for other and possibly more important work.

In a consideration of the effect of the war upon submarine policy, we are immediately concerned with the principal belligerents, and especially the central empires, whose sea policy has brought submarines into such prominence.

On the allied side, France entered the world conflict with a heterogeneous assemblage of submarines, about fifty in number, with the widest range of variation, both in regard to displacement and military characteristics.

The Russian submarine flotilla has played a very inconspicuous role in the operations that have taken place hitherto, and can hardly be said to have influenced submarine policy, either technically or strategically. By and large, the same may be said of the other allied powers, and the comparatively late entrance of the United States as a belligerent, if nothing else, would account for the inactivity of American submarines, so far as the major naval operations in the North Sea and in the waters surrounding the British Isles are concerned.

It may fairly be assumed, however, that since April last this country has profited at least potentially by the previous war experience of the western allies. Paradoxical as it may seem in the light of later developments, the last of the great powers to admit the desirability of or necessity for submarines was Germany, and that conclusion was reached only under the pressure of actual war, when it was manifest that the rest of her fleet was of practically no use. If one believes that the German Government has been preparing for many years in anticipation of the present war, it seems incredible, in view of the completeness of her preparedness in all other respects, that the submarine arm of the naval service was neglected and discredited up to the day that war broke out. It was assuredly no oversight on the part of the German authorities, for in several conversations the writer had with Admiral von Tirpitz in 1911 in regard to Germany's submarine policy the latter expressed emphatically as his opinion that he considered submarines to be in an experimental stage, of doubtful utility, and that the German Government was not at all convinced that they would form an essential or conspicuous part of its future naval programs. This opinion, which undoubtedly incorporated the opinion of his principal subordinates, was not expressed with any purpose of misleading, for it was a well-known fact at the time to every one in the profession that Germany's position in the matter of submarines was that of a third-class power.

When hostilities commenced Germany had 25 submarines in commission and was building perhaps half a dozen more. They were all of the Krupp-Germania type, and von Tirpitz explained almost apologetically that they had built a few just to be able to form some conclusions regarding them based on their own experience. It was evident at that time, however, that no great thought or attention was being devoted to their development, nor were ideas from outside sought.

Any casual student of European politics during the last 15 years knows that in every international complication that arose and threatened European peace Germany was also to be found on one side and England on the other side as potential antagonists. If Germany had foreseen every contingency and provided for it in advance, she must necessarily have regarded the participation of England as an adversary in the present conflict, or, in fact, in any conflict in which Germany was involved, as a possibility at least, even if a remote one, and she must also have foreseen that the participation of England would bring about the enforced inactivity of the German high-sea fleet.

She could also have foreseen the situation that now prevails, *i.e.*, the submarine branch of her naval service would be the only one that could deliver any effective blows against England. Under these circumstances, how is it possible to explain the utter failure of the German Government to comprehend, or, if it comprehends, to provide for the role that submarines are playing today? Is it possible the General Staff and the Reichs Marine-amt refused to recognize the possibility of England's participation as even a remote contingency, and that no appropriate preparation was made to meet it? It would almost seem so, for when England definitely entered into the conflict against Germany steps were taken in feverish haste to lay down over sixty submarines at once, and that number has since been largely augmented.

Estimates have appeared in print according to which Germany was credited with having over 700 submarines in her possession last May and that 1,200 would be in commission by the end of the year. It can hardly be possible that such an estimate has been made by any person familiar with the shipbuilding facilities of Germany, even making all due allowance for abnormal expansion of these facilities to meet the necessities of the occasion. It has been stated that drydocks would even be utilized for the purpose of erecting them, as if the problem were primarily one of ground space.

The entire shipbuilding capacity of Germany is very limited, compared with England, for instance, and the difficulty of finding highly trained and skilled shipbuilding labor such as is required for the intricate work of constructing a submarine would militate heavily against any sudden increase in the tonnage that could be turned out. Taking into account all the shipbuilding facilities of Germany, both private and governmental, making the most liberal allowance for the maximum extension of these facilities under pressure of war, bearing in mind at the same time the difficulty experienced in obtaining certain necessary machinery and appliances and in obtaining skilled labor, and deducting the number of submarines that have probably been lost or destroyed by the enemy, it does not seem possible that Germany had more than 200 submarines in commission last May. Of this number approximately two-thirds would be constantly available for duty, while the other one-third would be *en route* either to or from the various shore bases for the replenishment of supplies and for repairs.

To arrive at a fair or accurate estimate of the rate at which Germany can build submarines in the future is somewhat more difficult. Assuming, however, that all yards in the country were utilized exclusively for this kind of work and that no mercantile shipbuilding or repairs to the battle fleet were undertaken, which, of course, is far from being the case, the probability is that not more than 100 submarines could be completed every six months.

Information at hand would indicate that the actual recent output has been approximately 10 per month, of which the great majority are in the neighborhood of 800 tons to 1,000 tons displacement. Several groups of about 1,500 tons have also been commissioned, and quite recently the construction of a flotilla of eight so-called submarine cruisers of 2,800 tons displacement has been undertaken of which three or more are reported completed and the remainder will be ready for service by next month. These vessels will mount two 6-inch guns, besides two guns of lighter caliber, and embody the innovation of an armored conning-tower. This is more or less essential where the conning-tower constitutes the central control station of the vessel and at the same time is the most vulnerable part. It is only feasible, however, on vessels of great size, because of submerged stability considerations.

All the later Austrian submarines have been manufactured in Fiume and Trieste from German plans and constitute, in effect, a German submarine flotilla in the Mediterranean that has avoided the necessity of the hazardous journey from the North Sea through the Straits of Gibraltar.

Turkey and Bulgaria have not been contributory factors in the submarine plan of campaign.

The effect of the war on the submarine policy of Germany has manifested itself in a tremendous program of acceleration and access of numerical strength, with increase in displacement and radius of action, as hereinbefore indicated, to meet the exigencies of long cruises off the west coast of the British Isles, necessitated by the effectual closure of the English Channel.

It is not at all clear that before the war any of the allied powers, or for that matter the central powers, seriously anticipated or contemplated the possibility of ruthless submarine tactics against merchant shipping as at present employed by Germany. Nevertheless, some years before the war there was a lively discussion in the British press of certain alarmist literature, notably a book by Sir A. Conan Doyle, in which ruthless submarine warfare at its worst against merchant and passenger vessels was portrayed with grim accuracy. It was generally, if uncomfortably, dismissed as grotesquely fantastic, with at the same time a secret hope that eventual enemies might fail to apprehend the pregnancy of the suggestion. The initiation of the sinking-on-sight policy was justified by its authors as another of those convenient "military necessities," the results of which would sanction its utilization.

That it was not a predetermined policy before the outbreak of war appears to be evidenced by the fact of Germany's complete unpreparedness at that time to conduct submarine warfare, coupled with the further fact that the design of the earlier German submarines indicated the intention of anti-warship rather than anti-merchantman tactics. Be that as it may, when the German submarine campaign was finally launched against the Allies in all its ferocity, academic questions regarding the presumptive policy of its inception had to give way to the physical fact of its reality and the necessity of counteracting it by every possible means. At a very early stage in the war, certain important areas were defended by a series of nets with various devices to indicate the presence of a submarine in the net and so aid in its capture or destruction. Large numbers of high-speed patrol launches mounting a 2-inch or 3-inch gun were employed to hunt and shoot down exposed conning-towers or hulls, and destroyers were rapidly fitted with emergency rams to permit them to charge submarines on sight with a fair chance of success without undue damage to themselves.

The immediate effect of these tactics on the part of the allies produced the counter-measures of knife-edges and net cutters at the bow to facilitate penetration of the net, clearing lines and similar devices protecting all projecting parts to the same end, and housing periscopes to bring the top lenses in the housed position, below the clearing lines.

The larger submarines then under construction increased their armament to guns of 4-inch caliber to outrange the patrol boats, and the latest vessels with 6-inch guns are formidable opponents of a destroyer. The danger of ramming induced a radical increase in the length of the periscopes up to about ten meters in some

*A paper read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917. Reported in *Journal of the Engineers' Club of America*.

of the latest boats. By this means it is possible to keep a lookout in fairly rough weather with several feet of periscope exposed and at the same time maintain a sufficient depth of water above the vessel herself to practically preclude the possibility of successfully ramming. The conning-tower remains as the only vulnerable part in this condition, and the destruction of the tower, while serious enough, by no means entails the loss of the boat.

To reduce resistance to propulsion submerged and at the same time obtain sufficient rigidity in the free portion of periscope above the highest bearing, the use of the extremely long periscopes has necessitated an increase of the housing distance to the greatest practicable degree, the eye-piece in some cases being almost in the bottom of the boat when the periscope is fully housed.

The ubiquity of vigilant patrols and destroyers, frequently making no invidious distinctions between friend and foe, has necessitated on both sides a revised conception of quick transition from the surface condition to the submerged condition, whether statically or dynamically. The necessary sequence of operations to bring about this transition, which in time of peace were customarily performed consecutively, are now perforce executed simultaneously, and any practical expedient by which seconds may be saved is unhesititatingly adopted. Upon a given signal the engines are stopped, exhaust pipes closed, clutch to main shaft disengaged, conning-tower hatch closed, ventilators closed down, motors started, kingston valves and vents for flooding main ballast tanks opened, and the crew all stand by at battle stations.

To still further expedite this maneuver, the allied submarines navigate frequently with open kingstons, depending upon air-pressure in the ballast tanks to regulate the ingress of water. The Germans, on the other hand, maintain a partial vacuum in the empty ballast tanks, which in effect approximately doubles the head of water. As the tanks must, in the nature of the case, be filled while the vessel is still on the surface, the head of water can never exceed the draught of the vessel, and even this comparatively low head is steadily reduced by the filling of the tank. With a given total area of kingston valves, the increased rapidity with which the water will flood a tank containing a partial vacuum instead of air at atmospheric pressure will be apparent. The usual vent pipes to permit the escape of air from the tanks are also fitted, and these are opened as soon as the vacuum gage on the tanks indicates the reestablishment of atmospheric pressure. The partial vacuum in the tanks is obtained by pumping out the air with the usual high-pressure air compressors that are installed for air service purposes.

The system is open to the objection that an emergency might arise demanding quick submergence shortly after a previous emergence and, before sufficient time has elapsed, to produce underpressure in the tanks. As the time required is comparatively short, however, and even a few inches of vacuum are effective in increasing the rapidity of flow, this disadvantage is relatively insignificant.

At an early stage it was apparent to the German authorities that the expenditure of 20-inch or 18-inch torpedoes on merchant ships represented wasted energy; moreover, the number of tubes and torpedoes of that size that a vessel could carry was relatively limited. At the same time, the general policy of defensively arming merchant ships militated against the German practice of coming to the surface and leisurely sinking the victim with a few inexpensive bombs placed on board or several well-directed shots from the guns, for which two to three hundred rounds of ammunition could be stowed.

These considerations, taken in conjunction, indicated the desirability of evolving a new type of small torpedo proportionate to the work to be done, of which a larger number could be carried on board than would be possible with 18-inch or 20-inch torpedoes within equal limitations of weight and space. This led to the adoption of the 14-inch torpedo and permitted the installation of approximately twice as many tubes and torpedoes in a given design.

The experience of the war has taught submarine officers to make the most of the virtue of invisibility; showing more than the top of a periscope during the 20 hours of daylight in the summer months is an undue risk not to be taken without sufficient reason. The energy of the battery must be conserved, however, to be available when needed in an emergency. To that end, arrangements have been perfected to facilitate what is variously known as balancing, statical diving, or suspending. With a minimum expenditure of power, the vessel remains stationary in the submerged condition, with only the tops of the fully extended periscopes exposed. With the sensitive listening devices now extant it is of vital importance that this mechanism be as nearly noiseless as possible and that no air-bubbles escape to betray the presence of the boat. By housing the periscopes during this maneuver, nothing is visible above the surface of the water.

It is sometimes employed when close pressed to elude pursuit when the depth of water is too great to permit descent to the bottom.

Another method of economizing battery energy frequently resorted to consists in navigating the vessel with the ballast tanks full and ready for diving under the Diesel engine. The only exposed portion in this condition is the conning-tower fairwater, and that is not a measure of the actual reserve buoyancy, for the apparent freeboard is due to the dynamic effect of propelling the vessel forward in this condition with the stern diving rudders set slightly to rise. The hatches all being closed, the air for the engine is supplied by a quick-closing ventilator.

This operation was regarded dubiously before the war, but its success has justified its wide adoption, so that what was once considered a precarious expedient has now become commonplace routine. Doubts were felt regarding the possible effect on the crew of a sudden inadvertent closure of the ventilator supplying air to the engines and a consequent rapid drop in internal pressure. In practice the effect on the crew is *nil*, other than a momentarily disagreeable numb sensation in the ear-drums.

The use of nets in this war as a defense against submarines and the desirability of evading these entanglements by diving below them will probably lead in course of time, if it has not already done so, to the consideration of increasing the strength of the pressure hull to make submergence to a depth of 300 or 400 feet a practical possibility, instead of the working limit of 200 feet that generally obtains today. To accomplish this result a certain rather serious sacrifice of other military qualities will be, of course, inevitable.

During the first years of the war little success was experienced in combating submarines with submarines principally for the reason that their reciprocal invisibility militated against their finding each other except when one was on the surface. Later developments in submarine signalling and sound-detecting devices have made it possible, however, to hear a submarine even when it cannot be seen, and also to approximate its direction. That being the case, it is quite conceivable that a numerous flotilla of submarines submerged statically in suspected areas with only the periscope objective exposed might lie in wait until the sound of the enemy's propellers or the hum of the electric motors became audible. In all probability the sound of the propellers would be heard first and the comparatively high rotative speed should distinguish it from the propellers of an ordinary vessel. In any case a look through the periscope would resolve any doubt on the subject.

Proceeding in the direction whence the sound came, an effort would be made to locate the enemy's periscopes and get within torpedo range. Any submarines now in commission provided with the latest listening plates could perform the function of a submarine patrol with a certain degree of success, but it is evident that a submarine designed especially for this kind of work—in short, a contra-submarine—would logically depart considerably from the characteristics of submarines proper as we now know them.

The evolution of a radically different type would involve for every nation the creation of a flotilla of contra-submarines to oppose the submarines the enemy would send against her. It is, of course, possible to make a compromise design combining the essential characteristics of the submarine-*versus*-warship type with the submarine-*versus*-submarine type, but such a compromise is not compatible with the highest requirements of either and is likely to entail the weak points of both and the pre-eminent advantages of neither.

For that reason two distinct and separate types are to be preferred.

The contra-submarine will do practically all of her work submerged. Therefore the displacement should be sufficient to ensure satisfactory habitability, and a very powerful battery and large motor should be installed to give the maximum possible endurance submerged and the highest submerged speed at the maximum discharge rate of the battery.

On the other hand, battery efficiency expressed in output per pound of weight is highest when the individual cells are not too large, especially when the vertical measurement is at a minimum, nor is it desirable to unduly increase the voltage. Hence practical limitations are imposed which will possibly determine 500 to 600 tons as a satisfactory surface displacement.

Facility of maneuvering submerged also inhibits too great a displacement.

Everything that contributes to resistance submerged should be examined critically with a view to reduction or elimination. The conning-tower and periscope complex adds about thirty-five per cent to the total resistance, out of all proportion to its relative size. The periscopes naturally cannot be omitted, but a large reduction in resistance may be effected by restricting the function of the conning-tower to that of a simple entrance hatch to permit ingress and egress in heavy weather and reducing its section to the "irreducible minimum." If made of nonpressure-tight construction, it could be of elliptical section and still further reduce its eddy-making propensities.

In certain French submarines built before the war the idea of reducing resistance submerged was carried to the extent of eliminating the conning-tower altogether and fitting in its place a canvas weathercloth to protect the entrance hatch in heavy weather. Thus the boat was virtually destitute of an entrance hatch that could be safely opened when seas were breaking continuously over the deck. After a few disagreeable experiences the practice was discontinued. There is no good reason, however, why the conning-tower, or, properly speaking, the entrance hatch in this special case, should not be made housing to be elevated only when weather conditions require it.

Docking keels, bilge keels, and other power-consuming hull appendages should be dispensed with, to the limit of absolute indispensability.

As for armament, the same process of logical reasoning that induced Germany to adopt 14-inch torpedoes would obtain in this case, although the writer believes that still smaller torpedoes, say of 12-inch diameter, would be preferable.

In stalking an enemy submarine, it is not likely that more than one opportunity to fire at point-blank range would be presented, and with the extremely long periscopes now in use there is no means of ascertaining whether the enemy whose periscope is sighted is 8 feet or 20 feet or more below the surface.

With housing periscopes adapted to be used in practically any position, the length of exposed portion of periscope no longer indicates the depth of the boat, so the possibility of a torpedo going over or under the target due to this uncertainty is considerable.

To reduce the influence of this disability to a minimum, as many tubes as possible should be grouped for simultaneous firing, arranged at slightly divergent angles, with torpedoes set for various depths, so that dispersed fire is obtained on the principle of a shot-gun.

Such a group of tubes can more readily be fitted in the bow than elsewhere. It is important, however, that the contra-submarine should have as great an arc of fire as possible with the minimum necessity for training the boat in azimuth, for which reason a battery of perhaps four stern tubes could be installed. Broadside tubes do not lend themselves readily to this arrangement, especially as each group could only be fired on one side. This consideration, together with the difficulty of firing from bow tubes at point-blank range in a vessel of large displacement, constitutes another argument against unduly increasing the displacement of these vessels.

They should, of course, be self-sustaining, therefore equipped with Diesel engines to charge the batteries in not over four hours. Therein lies their greatest vulnerability, although in that respect they are in a similar case with any other type of submarine. During the period of battery charging at night, they must not only come to the surface and sacrifice the immunity of invisibility, but the noise of the Diesel engine exhaust is distinctly audible for a long distance and characteristic in its quality. If the exhaust be arranged above the water-line, it is directly audible. If an underwater exhaust be employed, the microphone of the listening plate on another vessel tells the story. From the two horns of that dilemma there appears to be no immediate escape, but it offers a promising field for ingenuity.

In stalking enemy submarines, either in the open or using a merchant ship as decoy, the element of chance naturally plays a conspicuous part. At least as much success will probably be attained when no decoy ship is used, for the reason that the noise of the decoy's propellers will tend to obliterate the sound of the enemy's screws. An extensive zone of silence as complete as possible is really the desideratum, and all internal noise must be entirely eliminated. Under these conditions a sufficiently numerous fleet of submarine patrols in the theater of operations would assuredly serve to cause the enemy some distraction other than the preoccupation of hunting down merchant ships, and this fact alone, not to mention its undoubted undermining effect on the enemy's morale, would justify its *raison d' etre*.

Manufacture of Smokeless Powder

In a German patent on a process of manufacture of smokeless powder it is stated that in order to increase the stability and plasticity of the powder, anilides of organic acids are added in which the imide hydrogen is replaced by a radicle, with the exception of ethyl or methylacetanilide. These anilides are particularly suitable as camphor substitutes, and owing to their lower volatility have a favorable effect on the stability of the powder.

Standard Propelling Engines for British Standard Ships*

In supplement to our article on British Standard Ships, which we published in an earlier issue (page 553 *Engineering*, 1917), we now give illustrations of the standard engines designed and built for these ships. The main engine design does not present any new features, and is fairly representative of that usually adopted for triple-expansion engines having cylinders 27 inches, 44 inches and 73 inches diameter by 48-inch stroke. The outstanding feature, which indicates that the design is of Clyde origin, is the front columns which carry the piston-rod guides, as against the slipper-type guide which is a feature of the North-East Coast design. Special attention has been given to details for convenience in machining and assembling, the piston type of valve for the medium-pressure cylinder, for example, being adopted chiefly on that account. The circulating pump, which is of the centrifugal type, 12-inch bore branches, is mounted with its engine on the main engine bedplate so as to enable it with its pipes and connections, to be fitted complete in the erecting shop. The reversing engine is of the usual all-round type, and an independent turning engine is provided.

All the designs, with the exception of the auxiliary machines, were, of course, prepared by one firm, who had extensive experience in machinery of this size for cargo vessels, and were issued to the various machinery contractors complete, together with full detail specifications of all the raw material orders and the finished items which it was arranged to obtain from subcontractors. A degree of detail quite unusual for this class of work was embodied in the drawings and information issued, so that even those firms who were not familiar with such work—some of them accustomed to a smaller class and others to the highest class of Admiralty work—would have no difficulty in knowing exactly what was required.

The advantages of manufacture to a common design were found of convenience in many ways as when, in the course of construction, one firm discovered defects in a soleplate casting; this was at once replaced by a similar casting from another firm, who were not at the time requiring that casting, failing which possibility of delay of weeks would have occurred with the erection of the whole engine. Another instance was the facility with which a replace main steam pipe branch-piece was immediately despatched to a vessel ready for trial trip, when the original one showed leakage on the first steaming of the engines. The greatest advantages of this manufacture of details in multiple were, of course, experienced by the sub-contractors for these details, as they were thus enabled to proceed with a very large number of each article exactly alike instead of each differing, perhaps only in very small points, to suit the arrangements prepared by individuals, but sufficient to prevent them being used for the first firm requiring delivery.

It can readily be understood that many of the small items in a modern cargo vessel's engine-room could be manufactured to better advantage by specialists, than by large firms whose plant is generally suitable for large work, the items of which are different for each vessel, and especially so when orders for scores of these smaller items could be placed at a single time. The orders for all the auxiliary machinery, also the various valves, valve-boxes, branch pieces, cast-iron and wrought-iron pipes, etc., were consequently issued in multiple, from a single source, and placed with firms who specialize in such work so that once they had prepared patterns and templates to the drawings they could manufacture these fittings for all the vessels, drilled and ready to fit in place. For instance, the main steam pipes were finished complete by tube-makers to drawings, having been so designed that the unavoidable inaccuracies in fitting boilers and engines in place could be taken up at the joints and thus overcome the delay which otherwise invariably occurs through having pipes made to fit the place after everything else is in position.

The smaller castings for the main engines were also ordered in multiple, thus avoiding unnecessary pattern-making, as all the firms on the Clyde were supplied with those castings from two sets of patterns in all. This procedure enabled the machinery contractors to concentrate their attention on the bigger things with the knowledge that the smaller things were, so far as they were concerned, looking after themselves.

The positions of the auxiliary machinery were arranged so as to give the least work in completing the vessel after it was launched, the positions being so chosen that all erection could be completed in the shipyard before the launch, the various connecting pipes being of the simplest form while providing all the conveniences for working usually found in first-class work.

The feed filter, which is of the gravitation type using coir fiber, open to observation and replacement while the engines are working, is embodied in the main engine hot-well attached to the air pump, so that it is completely fitted in the engine works and no pipes and connections at all are required for it. The feed heater is of the well-known mixer type, and is also embodied in the main engine hot-well, the whole making a very compact arrangement with the minimum of fitting work. The evaporator is of the vertical type, capacity 25 tons per day, and conveniently arranged at the back of the main engines.

The winches are of the usual plain cargo-vessel type and number, arranged to exhaust to a winch condenser placed in the engine-room. The winch condenser is of ample size to deal adequately with the exhaust from the winches and so facilitate expeditious discharge of cargo. A general service donkey and a harbor-feed donkey are provided, both alike, of the single direct-acting type, with 9½ inches diameter steam cylinder, 7-inch diameter water cylinder, 18-inch stroke, and capable of feeding boilers in port or at sea, the harbor-feed donkey being fitted with automatic control from a float which operates with the water from either main engine air pump or winch condenser.

The ballast donkey is of the single direct-acting type, 11-inch diameter steam cylinders, 14-inch diameter water cylinder and 24-inch stroke, to quickly discharge water ballast from the various tanks throughout the vessel.

Owing to prevailing circumstances the use of copper piping had to be avoided. Wrought iron has been largely used throughout, only the very small pipes being made of copper. As a result the total weight of copper piping is less than one-sixth of that usual in this class of vessel.

The boilers—three in number—are of the well-established multitubular return-tube type, 15 feet 6 inches diameter by 11 feet 6 inches long, for 180 pounds working pressure, working under Howden's system of forced draught. They do not present any special features, although it may be mentioned that the original design, prepared for the minimum among of workmanship and expeditious construction, had to be modified in later boilers on account of the present demands on steel works for large plates, so as to enable those available to be utilized. The principle of manufacture in multiple was adopted for boiler parts also, this applying to such items as tubes and furnaces, the latter being finished to one set of templates for all firms.

From Engineering

Standard triple expansion engines for British standard merchant ships—front view

*From *Engineering*.

The Banana as a Food*

"The banana is a useful fruit that can with profit enter liberally into the child's dietary provided it is fully ripe or well cooked. If eaten baked in the yellow stage of ripeness or if eaten raw when fully ripe, the banana makes a delightful and highly nutritious article of food. Its composition does not warrant the use of the banana as the main component part of the child's dietary, but it can compete well with other fruits and is decidedly to be preferred to candies. The nutritional value is relatively high, approximately one calorie per gram of pulp; and its carbohydrates, when it is fully ripe or cooked, are not less assimilable than those of cereals and potatoes. In the raw food the digestibility is directly proportional to the ripeness of the fruit. There is no positive evidence that the banana influences bowel movements. In the many tests there was no suggestion whatever of any deleterious effect from consuming large amounts of fully ripe bananas. Prolonged use of the underripe fruit, on the other hand, developed undesirable symptoms. Ripeness can be readily determined by the color and texture of the peel. In ripening, the peel changes in color from its original deep green to a dark brown. In this change the color of the banana passes through several yellow stages which are generally taken to be signs of ripeness, but a yellow banana is not necessarily a ripe banana and if consumed raw while it still has a green cast to the yellow color, as is frequently done by children on the streets, the avail ability of its carbohydrates is comparatively low and the effect on the child's digestive system injurious. The banana ought not to be eaten raw until after the brown spots begin to appear. It is at this stage a full golden yellow and in its most attractive appearance. A completely browned skin is not in itself a sign of overripeness, and such fruit should be judged by the texture of the pulp. The brown color of the peel, however, should not be confused with the darkening due to bruises. An injured banana is soon invaded by moulds and yeast cells, both through the abrasions and the broken end, so that the banana 'finger' should not be broken from the 'hand' or stem, but cut off in such manner as to leave a good margin between the cut surface and the pulp. The banana properly handled and allowed to ripen to its most beautiful color and texture is a wholesome food, uncontaminated by dirt and pathogenic germs, even if purchased from the push cart in our congested streets."

*From an article by Pease and Rose in the *American Journal of Diseases of Children*, November, 1917. Investigation carried on in the Department of Pediatrics and the Laboratory of Pathological Chemistry, New York Post-Graduate Medical School and Hospital.

German Aeroplane Engines

A SMALL, but most instructive exhibition of captured German aeroplanes and engines, has been recently opened in London, the following account of which appears in *Engineering*. The object of the exhibition is educational, and for the convenience of manufacturers and others interested in aero-engine design, several engines have been dissected, and sets of the component parts, sectioned where necessary to show the construction, have been mounted on large boards, alongside specimens of the engines to which they belong. There are altogether some dozens of captured engines either officially on view, or rendered visible, by the courtesy of the attendants, to those interested. The aeroplanes, which are five in number, occupy another part of the hall.

Perhaps the most striking fact in connection with the engines is that, with a solitary exception, they are all of the vertical six-cylinder water-cooled type. German aero-engine design seems to have settled down along the lines of a straight forward racing-car engine, not perhaps of extraordinary lightness for the power developed, but reliable, durable and above all, easy to manufacture in quantities with ordinary labor and shop equipment. The one exception to this type is a specimen of a 100-horse-power Oberursel engine which formerly adorned a Fokker fighting monoplane. This engine is of the nine-cylinder rotary air-cooled pattern, almost indistinguishable from the Gnome rotary engine, which is largely used by the British authorities. It has the typical Gnome pistons carrying automatic inlet-valves in their heads, and in other features the resemblance is exceedingly close.

Reverting to the standard six-cylinder engines which really constitute the exhibition. these comprise the following types and sizes, namely, Mercédès 160 horse-power and 260 horse-power; Benz 160 horse-power and 220 horse-power; and Argus 120 horse-power and 200 horse-power. The Argus engines differ from the others in the fact that the cylinders are in pairs, one sheet-iron water-jacket enclosing two cylinders, but as these engines have not yet been sectioned it is not possible to see the details of the cylinder construction. One of them is equipped with an English carbureter and English magnetos, and we believe that many captured German engines have been found thus equipped. It is said to be the German practice to design their engines to take British accessories and so to be able to utilize valuable fittings stripped from our machines which have come to grief behind their lines.

The Argus engines are also noticeable by reason of the amount of labor spent on the elaborate finish of unimportant parts. This is certainly not a typical failing of German engines, for these as a rule display a commonsense in the matter of finish, and of simplicity of detail, which our own manufacturers might emulate with advantage. On the whole, in so far as it can be inspected, the Argus engine does not appear to have any extraordinary merits, while in certain details, such as the use of loose cams secured by taper pins, the design is anything but commendable. On the whole, one probably would not be far wrong if he said that an equally good, or better, engine could be made for less money.

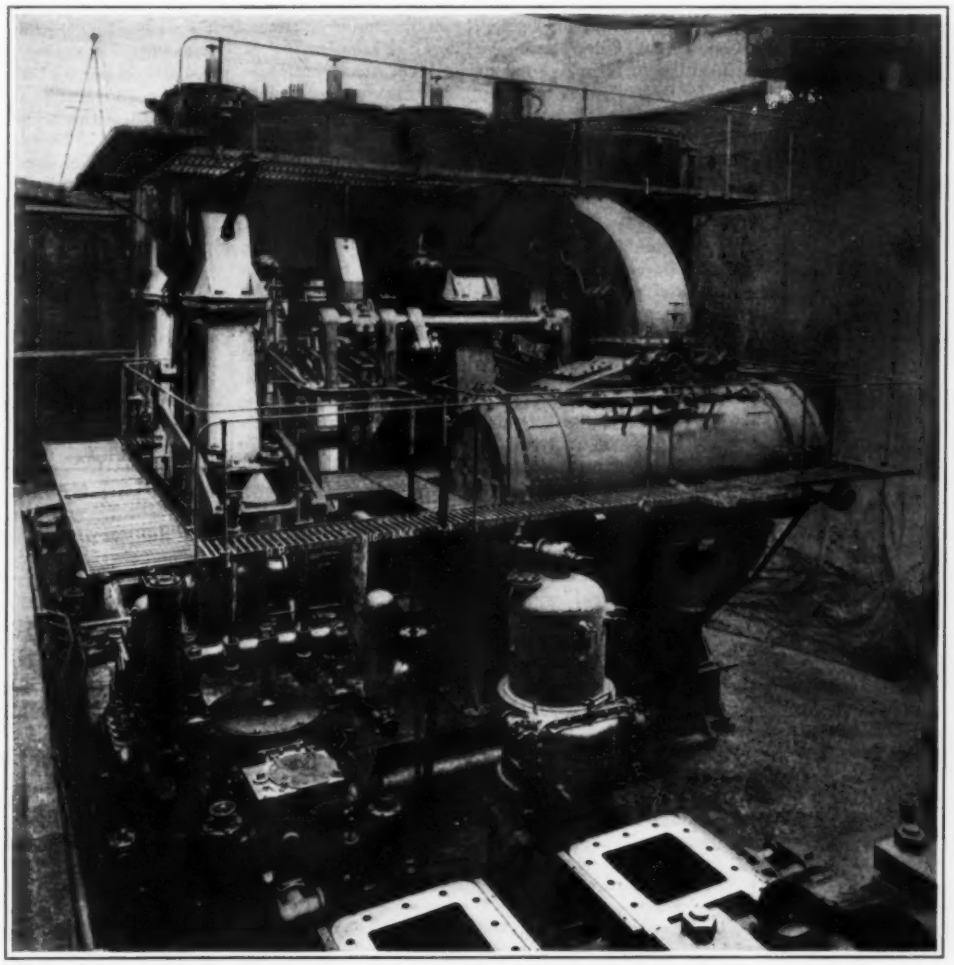
The real interest of the exhibition to designers of aero-engines lies in the remaining types, the Benz and Mercédès. These appear to represent the outcome of German experience as to what an aero-engine ought to be, at any rate for such work as long-distance bombing flights if not for more spectacular duties. The Gotha biplane carries two 260-horse-power Mércdès, the A.E.G. is similarly equipped, and the Rumpler biplane is fitted with a single engine of the same power and pattern. Benz engines of 220-horse-power are carried in the Aviatiks and the Agas. The Albatross two-seater carries a 160-horse-power Mercédès.

The Benz and Mercédès engines are, broadly speaking, of the same general pattern, each having six independent vertical water-cooled cylinders, with sheet-iron welded jackets, and both representing the final development of their racing-car prototypes. They weigh, we understand about 3.75 pounds per normal brake horse-power at ground level, this figure comprising a complete engine, but without radiator, fuel, oil, or tanks. Of the two the Benz is slightly the lighter per brake horse-power, and from the manufacturing point of view the details of its design are generally preferable to those of the Mercédès. The 160-horse-power Mercédès aero-engine of pre-war days had cylinders in pairs, like those of the Argus, and the crankshaft was also of peculiar design, but these features have been abandoned in the modern engines.

Dealing with the points of difference, the Benz cylinders are of cast-iron with solid valve-seatings arranged vertically in the head, whereas the cylinders of the Mercédès are of steel with exhaust and induction ports screwed in at an angle. In both sizes of the Benz engine the inlet and exhaust valves are duplicated, and are operated by a camshaft housed in the crankcasing. In the Mercédès engine a central overhead camshaft is adopted and duplicate valves are only used in the larger size. The casing of this camshaft appears a very costly piece of work, and the Benz design seems unquestionably better. The Benz pistons are of cast-iron, with three rings at the top and no scraper ring. A perforated steel cone is rivetted to the inside of the piston-head, the apex of the cone forming a small seating on the center of the gudgeon-pin. The function of this cone is probably to assist the lubrication of the pin, although the support it affords to the latter may be useful. The piston of the Mercédès is formed by screwing a steel head, carrying the gudgeon pin bosses, into a cast-iron skirt. The design of the connecting-rods also shows considerable difference. The Benz rods are of parallel tubular form, involving only lathework of a simple kind, whereas the Mercédès rods are of the usual I-sections which give greater trouble in machining.

Coming to the crankcase, in both engines the lower half of the case forms a support for the crankshaft so that the bearings and connecting rod-ends are very inaccessible when the engines are erected. This would appear to be an objectionable feature of both designs, unless it has been found that sufficient rigidity is not obtainable otherwise. There are no ball-bearings for the crankshaft of either engine, except for the thrust bearings. Oil cooling is arranged for on the Benz engine by a number of horizontal tubes passing transversely through the sump. A cowl on one side of the casing directs air into the tubes, and a similar cowl on the other side, facing backwards assists the draught through them. In the same engine the crankshaft bearers are also cored transversely from side to side, so that the air-circulation may tend to cool the bearings, and through two of these ports the air is drawn to the carbureters. The induction-pipe system of the Benz compares favorably with that of its rival and the water circulation system seems pronouncedly superior. On the other hand the circulating pump of the Mercédès, with its shrouded impeller and volute discharge is of much superior design to that of the Benz.

The general impression left on the mind by an inspection of the captured engines, is that the Germans have carried the standardization of type infinitely further than we have, and therefore have placed themselves in a position to manufacture aero-engines with the maximum rapidity and cheapness. We have certainly captured many hundreds of German engines, and it is only reasonable to suppose that the collection at the Agricultural Hall is fairly representative of the bulk of those now used against our troops in Flanders and our civilian population at home. It is therefore a matter for remark that, except for the solitary Gnome engine, the Germans appear to have abandoned, or never to have used, the rotary type, the radial fixed type, the Vee type, the opposed type or the Broad Arrow type, not to speak of the numerous variants which each of these types comprises. They pin their faith, apparently, to a simple engine with the minimum number of parts, and devote their energies to increase of numbers rather than to the development of types.



From Engineering

Standard triple expansion engine for British standard merchant ships—rear view

Preservation of Fermentation Organisms in Nutrient Media

THE *Comptes rendus des travaux du Laboratoire de Carlsberg* (1917, vol. ii., part 6) contains an important article by Prof. A. Klocker on the preservation of fermentation organisms in nutrient media. Hansen's conclusion that a 10 per cent solution of cane-sugar forms an excellent medium is confirmed, but beer wort is also very good. The Pasteur flask is undoubtedly the best form of vessel for prolonged preservation. The present observations were made, during a period of more than thirty years, on 820 cultures of yeasts and moulds. These included Saccharomycetes, Schizosaccharomycetes, Torulæ, Mycoderma, Endomyces, Monilia, Chalara, Oidium, and Mucor. For the most part the nutrient medium employed was a 10 per cent solution of cane-sugar, in which 461 cultures were grown, but 290 cultures were made on beer wort and sixty-nine on other media. Of the 461 cultures on cane-sugar solution (231 of these being Saccharomyces) 403 survived, while 58 perished. In the case of the 290 cultures grown on beer wort (190 Saccharomyces) 268 survived and 22 perished. Thus it must be concluded that fermentation organisms can be kept alive for upwards of thirty years. The exceptions to this rule are: (1) The asporogenic varieties of Saccharomyces; (2) *Saccharomycodes Ludwigii;* (3) Schizosaccharomyces; and (4) *Aspergillus glaucus*. Of the first only 44 per cent survived on cane-sugar and 21 per cent on beer wort, of the second only one in nine survived on cane-sugar for more than 7.5 years, but all five cultures on beer wort survived for twenty-five years. Only two out of five cultures of Schizosaccharomyces on cane-sugar survived, but ten out of eleven of those on beer wort were living. Of six cultures of *A. glaucus* only one survived, and two of the remaining five perished in less than two years.

Automotives in the Great War

A Review of What the United States Is Doing

By Coker F. Clarkson, General Manager of the Society of Automotive Engineers

"Of those who are now pressing forward and contributing their services for the purpose of accomplishing the ending of the war, none have given greater or more patriotic service than this body of highly trained, highly educated, and high-minded motor-truck specialists." Thus spoke the officer in charge of the transportation division of the Quartermaster Department, of the work of members of the Society of Automotive Engineers on standardized designs of United States war truck. During the year 1916 this officer had maintained close relations with the Society of Automotive Engineers, and in conjunction with a committee of the Society prepared a draft of military truck specifications for the department. The Truck Standards Division of the S. A. E. entered earnestly into cooperation with the quartermaster department and representatives of other Bureaus of the War Department, with a view to providing suitable specifications for military trucks. The Society called officials of the National Automobile Chamber of Commerce into conference, and asked representative truck manufacturing companies to send their chief engineers to a meeting to consider the military truck needs of the Government. This resulted in the holding of a convention of fifty or more engineers and others. The action taken was to appoint a committee which later became the Truck Standards Division of the S. A. E., constituted of engineers of five companies manufacturing trucks, five companies assembling trucks, the engineer of a truck factory not making the type of truck being deliberated upon, and the truck engineer of the Quartermaster General's office. After joint meetings of this committee with the War Department Motor Transport Board, a revised set of military truck specifications was issued last April.

Later a conference was held of engineers of companies engaged in the production of various units entering into the construction of the trucks, including the engine, transmission, axles, springs, universal joints, frame, radiator and fan. The purpose was not to modify the War Department's specifications but to bring about such interpretation of them as would result in the production of parts, as well as complete trucks, in sufficient number to supply the Army adequately with trucks of proper type, the assembly units to be interchangeable so far as possible; and to a limited extent the parts of units of different make were to be interchangeable. The manner in which truck and parts manufacturers cooperated in this work was most gratifying and afforded additional manifestation of patriotism in a matter of vital importance in military operations.

In July the Government announced that it had decided as a matter of military exigency to standardize complete designs of war trucks, practically all the component parts thereof being interchangeable although made at widely scattered points. Committees, constituted in very large part of members of the Society of Automotive Engineers, were put to work promptly. Early in October samples of the U. S. Heavy-duty War Truck (Class B, rated by the Government at 3 tons, but of practically 5 tons Commercial capacity) were on the road, several samples of the U. S. Medium-duty War Truck (Class A, Government rated 1½ tons, but substantially a 2-ton Commercial truck) have been in operation for some weeks, and by the middle of this month samples of the Light-duty War Truck (Class AA, ¾-ton) will be under test. These models are new, specially designed from the ground up in almost every respect. The detail and broadest experience of the best specialists and experts has been availed of, and the trucks will meet most exacting requirements of war conditions. It will be possible to produce them in as large quantities as needed. The stock of spare parts necessary to send to the theaters of operation has been decreased enormously, simplifying very greatly the maintenance processes which have been distracting to the armies of our Allies, who have been obliged to use trucks of many different designs and makes.

In designing the United States war trucks the engineers have naturally followed closely the experience gained by the Allies, as well as that had on the Mexican border by our manufacturers and Army officers. They have put at the command of the Government the best products of their brains.

The public does not appreciate fully the value of the scientific and technical organizations back of the factory engineers. While all automotive engineers are competitors in a selling way, a close and confidential scientific basis underlies their work as a group and individually. Obviously this has had a commercial effect on the motor car, the motor truck, the motor boat, the airplane, the farm tractor and other automotive products. It has much to do with progress toward ideals sought by all thorough engineers.

A great part of the efficiency of the motor car and of the motor truck of today is due to the splendid manner in which the proceedings of the Society of Automotive Engineers have been conducted by its members. If each of the manufacturers had worked solely on the knowledge of the engineers employed by him, we would not yet have seen cars of such perfection as has been attained, or cars sold at the relatively very low prices of today. In a word, the enormous and spectacular growth of the automobile industry and the wide use of cars are more the result of technical organization of engineers and builders than of any other one feature of the industry.

The non-technical mind does not really appreciate the vital importance of standardization. To the average layman "standardization" frequently means that each and every car has an engine, clutch, transmission, frame, springs and axles of approximately the same general or identical makeup. Fundamentally in the commercial sense it is none of these big units that causes trouble to the automobile engineer or builder, or needs standardizing. The comparatively small things, different merely because they are different and for no good reason, are the things that keep purchasing departments in hot water, delay production and increase cost; not to speak of delayed and increased work of designers.

The tube mills reported to an S. A. E. investigating committee some years ago that not less than sixteen hundred different sizes of tubing were being called for by the motor-car trade. Few, if any, standard sizes could be stocked because of the minute though immaterial difference in the specifications of each individual case. Before commercial standardization was established by the Society of Automotive Engineers, there were innumerable special dies, gages and jigs. Over six hundred distinct lock washer designs were specified between the bolt sizes of $\frac{1}{16}$ and $\frac{5}{8}$ inch, whereas three dozen were more than sufficient. Metals and metal alloys of every conceivable analysis were being ordered.

These are merely surface examples indicating how the lack of standardization complicated engineering, purchasing and manufacturing problems, to say nothing of the enormously increased cost of the finished product, due to lack of uniform manufacturing limits and patterns.

The Liberty airplane engine and the War Trucks are not examples of standardization in the commercial sense, but of military designs dictated by war needs. The standardization by the Government of the necessary designs of all kinds of self-propelled vehicles operable on land, sea or in the air, is one of the chief factors in determining the outcome of the great war. A very large number of war emergency machines are now being manufactured after designs submitted by automotive engineers working in cooperation with army officers. The term "automotive" includes the automobile, aeronautic, tractor, motorcycle, marine and stationary gas engine fields—in fact every type of self-propelled vehicle. The design, production, operation and upkeep of these classes of apparatus are of the utmost importance in time of peace. During a period of war the problems become multiplied many times because of their magnitude and the pressing importance of speed in their solution.

In the last analysis war as fought today is substantially the matching of great engineering enterprises. In the long run the side with the best engineering genius (including productive and organizing ability) will win the contest. The ramifications of engineering accomplishments are infinite. They include the automotive, mechanical, civil, mining, electrical, chemical, sanitary, marine and railway fields, not to mention others of scarcely less importance. All these are interrelated and interdependent.

The organization of the motor transport service required by modern armies is a problem worthy of the best engineering talent, and one in which the automotive engineer has done splendid work. The unusually severe service conditions make the problems to be met in keeping a fleet of army trucks in operation far more serious than those encountered in normal peace service. As a result of years of preparation and experience of the S. A. E. along standardization lines, the Government now has in production War Trucks which are not only rugged and finished as designs, but capable of being produced rapidly, and simple and easy to repair, the parts being made with a view to easy renewal, and absolute interchangeability. For many years the Society has been carrying on an extensive program of standardization. In every possible case the standards created by the Society have been made use of in the design of these War Trucks, what is quite as important is the fact that a S. A. E. organization accustomed to producing standardization work was in existence and proceeding smoothly.

The work of the Society members has not by any means ended with the completion of the designs. The Government organizations in which such matters as the production, inspection and operation of automotive apparatus will be handled, are made up largely of automotive engineers, a surprising percentage of whom are members of the S. A. E., who have entered the Service. The Engineer Corps will use a large number of trucks for the handling of materials. These will be for the most part probably of the types designed by the Quartermaster Corps in cooperation with members of the S. A. E. Light, high-speed trucks to act as airplane tenders will be employed by the Signal Corps. The medical department will use the same chassis, the Class AA three-fourths ton truck designed by the Quartermaster Corps organization. The Marine Corps and the Navy Department also will use this truck in considerable number. Incidentally, it will be put into service in quantity in this country by the Post Office Department. The first Government-owned motor vehicle postal service was established in Washington in October of 1914. This service has been extended to Boston, Buffalo, Chicago, Detroit, Indianapolis, Nashville, Philadelphia, Pittsburgh and St. Louis, and according to schedule was to supersede contract service in Brooklyn and New York the first of this year. As an indication of the efficiency of this service, it can be stated that in one of the cities where it was in operation during one year, the motor trucks engaged in the transportation of mail between the depot and the post office were scheduled to make 384,526 trips, and there were only 132 failures, or one failure to every 2,913 trips. Government-owned motor vehicle service will be extended as fast as conditions permit. Experience has demonstrated, the Postmaster General reports, that trucks of the same size should be of a single type for the reason that when different kinds of trucks are used, it is necessary to keep in stock repair parts for each type. When chauffeurs are compelled to familiarize themselves with the operation of trucks of different kinds they render less efficient service than where they are required to learn to operate a truck of a single type. It is therefore argued that the department should adopt a standard truck for use throughout the service. This can be accomplished in either of two ways: First, by adopting one of the standard makes of truck best suited to the needs of the service, or, second, by adopting a Government design of truck. The first plan is not believed advisable because it would give one company a monopoly of the business and stifle competition. For that reason it is thought by the department that the second plan should be followed.

The operation of motor routes not only represents a more economical form of mail service to the rural communities, but also permits of the establishment of a wider postal zone from the larger and more important trading and postal centers. This means a better supervision of the service and the extension of the local zone rate on parcel post from the larger towns to a vastly greater number of families, giving them improved facilities for trading and at the same time increasing the utility of the parcel post feature of postal activity. These are considerations that demand the most careful attention in these times of excessive costs for foodstuffs and other necessaries of life.

A considerable number of contracts have been awarded requiring the use of motor vehicles in the transportation of mails in the star route service, resulting in material reductions in schedule running time. By this means mail is not only delivered to a large number of post offices of considerable importance located on branch lines of railroad where trains do not arrive early in the day, or at points more or less remote from the railroad, considerably earlier than would otherwise be possible, but where rural delivery routes emanate from such offices the expedited schedules on the star routes has had the effect of causing the mail from surrounding cities to be delivered on such rural delivery routes twenty-four or forty-eight hours earlier than formerly, with the equivalent advances in the dispatch of outgoing mail.

In the Ordnance Department the necessity for greater speed and tractive effort, as well as the increasing

scarcity of horses, have made necessary extensive motorization of equipment. Accordingly, another group of automotive engineers, S. A. E. members for the most part, familiar with the design of tractors, has been working on the problem. Heavy ordnance, which heretofore it would have been impracticable to move successfully, is now drawn over ground almost impassable otherwise than by means of this modern motive power. In addition to the tractors used by the Ordnance Department, a large number of four-wheel drive trucks are provided for the handling of ammunition. The accomplishments made possible by the use of the so-called tanks, form one of the most interesting chapters of the great war. The troops of this country will be provided with equipment of this character second to none in use by the Allies. It may be noted with just pride that the work involved has been in the hands of competent automotive engineers, many of them being representative S. A. E. members.

The motorcycle as now used for war purposes is made in two and three-wheel vehicles for dispatch work and for transporting machine guns. Here again the Society has rendered effective assistance to the Government in the standardization of parts, the Secretary of war having delegated officers of the Quartermaster Corps to confer with a Society committee on problems relating to the development, standardization and use of the motorcycle. The work of the Society's committee on this subject compares favorably with that of other committees and individual members already mentioned.

The automotive engineers have had a most important part in the conduct of the Government aircraft program. It is well known that the development of the Liberty Engine is properly credited to engineers who are members of the Society of Automotive Engineers and whose work has been greatly facilitated by the present and past activities of the Society. Due credit, of course, must be given to the Allied Governments for data furnished to our engineers who designed the Liberty Engine, but it should not be forgotten that this engine is strictly an American product, having been designed for rapid production, standardization and interchangeability of parts, factors not realized to the same extent in other designs. The benefit which this will have in increasing the effectiveness of our fighting contingents at the front can scarcely be over-estimated. The aviation engine is of course a high-strung piece of apparatus, one that must develop great power with minimum weight. The engine operates under full load and at high temperature practically all the time, so that its depreciation is relatively rapid. This in turn greatly increases the service problem and new parts must be supplied frequently in order to keep the maximum number of machines in operation. Here again we realize the importance of standardization and the necessity for absolute interchangeability, factors long appreciated by automotive engineers and practiced especially in the automobile industry in this country. The Society is justly proud of the work its members have done in connection with the production, inspection and upkeep of aeronautic apparatus. There is no more important work that they can do. In addition, the possibilities for development in the aeronautic field following the war are almost unlimited. A careful study is being made in connection with the National Advisory Committee for Aeronautics looking to the developing of a practical type of airplane for carrying mails, and the details are being worked out for the establishment of a number of airplane routes between several of the commercial centers, to be put into operation as speedily as satisfactory machines can be obtained for the purpose.

The submarine problem may possibly be solved by the adoption of one of the designs of large seaplanes now being perfected. The development of such types of aircraft is rapidly progressing and its activities are expected to have an important bearing upon the outcome of the war. The flying-boat no longer is a matter of speculation. It has proved possible to build a machine with the seaworthy qualities of a small yacht and at the same time able to take the air, for the purpose of locating and destroying submarines. The seaplane is not, however, the only type of craft for marine use in attacking the submarine, developed by the automotive engineers. The so-called submarine chaser is another of their war products. The design and construction of engines used in many of these submarine chasers constitute another of the problems that automotive engineers have handled with marked success. The production of the boats by standardized processes has been a very great achievement.

The development of small stationary or semi-portable units for the operation of the wireless set, the searchlight, pumps, isolated electric lighting plants and machine tools in portable repair shops, is another of the matters handled by automotive engineers. The machines mentioned perform highly important functions in the great military organizations of modern times and those responsible for their design and operation deserve equal credit with those who have contributed to the more spectacular forms of modern warfare.

The development and production of the farm tractor constitute a branch of automotive engineering of equal importance with that having to do with any direct military activities. The farm tractor is playing a tremendous part in the production of food. It is well recognized by all who have investigated the subject that the total production of food in this and other countries can be further increased enormously by the application of the farm tractor in many forms, small as well as large.

S. A. E. members are performing valuable service in the prosecution of the war in innumerable ways. In any branch of the service whether here or with our men in France, where automotive apparatus is made or used, there will be found the automotive engineer striving to do his part, always willing to cooperate with his fellow men and always looking for more work to do.

Science of Bricklaying

Increasing the Strength

In the best structures the finished pile of brickwork will crush under a much smaller load than will the individual bricks, while the crushing strength of the mortar by itself is comparatively small. Dr. Bohme, of Berlin —we are not above taking a leaf out of the enemy's book in this matter—has tested cubes of bricks 10 by 10 by 9.5 inches and found that the composition of the mortar has a distinct influence on the strength which the wall will develop. One series of bricks used had a crushing strength of 263.2 tons per square inch. With mortar composed of one part of lime to two of sand the cube crushed under only 116.2 tons per square inch, or 44 per cent of the crushing load for the individual bricks. With mortar of seven of lime to one of cement to six of sand the strength was 48 per cent, with one of cement to six of sand it was 55 per cent, and with one of cement to three of sand it was 63 per cent. In tests carried out at Toronto, piers about nine inches square in section by twenty-four inches high had from twelve per cent to twenty-nine per cent of the strength of the single bricks when laid in lime mortar, and twenty-six per cent to sixty-eight per cent when laid in cement mortar. With piers tested at Watertown, twenty-four inches to one hundred and twenty inches high, the ratio was from eleven per cent to twenty-six per cent for lime mortar and from seven per cent to eighteen per cent for lime. The Institute of British Architects tested piers 18 inches square by 72 inches high, and found strengths of thirteen per cent to twenty-two per cent for lime and seventeen per cent to 47 per cent for cement. These tests are comparatively ancient history, having been made some years ago, but they indicate two facts which have been confirmed and amplified by later results: that the strength of brickwork is greater in very small volumes than in larger, and that mortar containing cement gives better results than does mortar containing lime.

A single brick, or one or two bricks cemented together, suffers a pure compressive stress when subjected to a load. It is in the same state as a rail would be if laid along the sleepers and making good contact with them. Under these circumstances, the brick will resist increments of load up to the point when the adhesion of its individual particles is overcome and it is pulverized. But in a wall of any appreciable size the bricks act as beams, as does the rail when laid in the ordinary way between transverse sleepers. The bricks are forced to act in this way because of their own irregularity of shape and of the irregular yielding of the mortar in which they are laid. The effect of both these circumstances is that individual bricks, or most of them, become unequally supported along their under faces, and unequally loaded along their upper faces, a bending or beam effect being introduced. Consequently brick piers begin to fail by transverse fractures of the bricks, which gradually become a conglomeration of half-bricks. They never have the opportunity to develop the full crushing resistance of which each is individually capable. When the mass tested contains only a few bricks the sum total of their irregularities and of the irregular yielding of the mortar is small, consequently the bending effect on the bricks is much reduced, and they show a much higher compressive strength. It is found that this diminution of strength with increasing volume continues up to about six to eight cubic feet. Above this volume the individual bricks are exposed to the maximum bending conditions, and the strength remains constant. It may be asked what bearing this fact has on actual building construction, since no wall or pier of any importance would be of such a small size. The import lies in the fact that in the past it has often been the practice of designers to infer the load which a wall will bear from tests of two or three bricks cemented together. Such tests will give too favorable results, and the test piece should occupy at least eight cubic feet.

The troublesome breaking-up of the individual bricks occurs because the mortar yields under pressure at a different rate from the brickwork. Thus, if under a certain load the brick compresses 1.100 inches, the mortar may compress 2.100 inches, these figures being only for the sake of comparison, and not necessarily what would exactly occur. If the bricks are exactly rectangular and a skilled operator performs the work, the layers of mortar between the courses will be of even thickness. Consider, for simplicity, two courses of brickwork with a layer of mortar between. The lower course shortens by 1.100 inches and the mortar by 2.100 inches, so that the upper course, in addition to shortening by 1.100 inches, descends bodily by 3.100 inches. Under these circumstances no bending strain occurs, and the whole mass remains sound, but if the bricks are not truly rectangular the phenomenon is much complicated. The joint will not now be of even thickness, and the part which is thicker will shorten by more than that which is thinner. Thus, the upper bricks tend to fall out of the horizontal in descending; this exposes them to a bending action since they are held to each other by the vertical joints. The aggregate result is to fracture the bricks eventually, but the vertical joints will probably begin to disintegrate long before that. The figures given are, of course, greatly exaggerated for two courses, but results of that order, or more, might be expected in a pier of many courses. It is easily seen from the above that the whole trouble would be eliminated by using mortar which compresses at the same rate as does the brick. The pier would then behave as a homogeneous material, and the shape and arrangement of its constituent parts would be immaterial. A mortar rich in cement, or simply neat cement, fulfils this condition much more nearly than any other kind, and, therefore, gives the best results for strength.

Although it is proper to have a wide margin between the ultimate crushing load of the pier and that which it has to bear, yet this is retarded rather than helped by wasting over ninety per cent of the strength of the bricks by using unsuitable mortars. Since it is impossible to ensure ideal regularity of the bricks or compressibility of the mortar, it is well to arrange the former so as best to withstand the bending action to which they are subjected. It is obvious that one way is to lay the bricks on edge instead of flatwise. In ordinary practice the vertical joints are broken at every course, the bricks being laid flatwise. By allowing the vertical joints to run unbroken through, say, three courses, the bending will be resisted by the combined action of groups of three bricks instead of by single bricks. The gain in strength is at once seen to be considerable.—*London Daily Telegraph.*

A Large Electromagnet

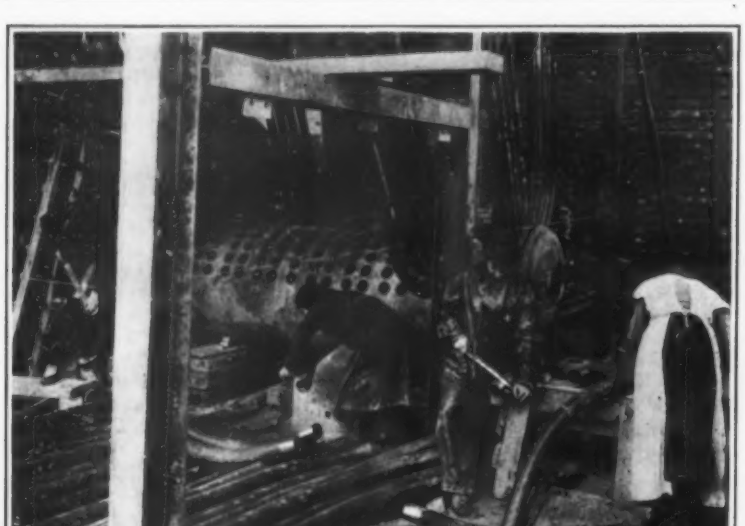
For the study of magnetic phenomena of anisotropic liquids, also at low temperature, Dr. The Svedberg, of the University of Upsala, Sweden, has a large magnet constructed by Messrs. J. L. Rose, of the same city, which is interesting for its size, power and simple construction. It consists of a rectangular frame, 77 cm. by 55 cm., built up of four bars, the cross-section being 15 cm. by 7.5 cm.

The frame is fixed to a cast-iron base, and the magnet can either be used with the frame vertical, when the magnetic axis is horizontal, or with the frame horizontal. The two pole-pieces are cylindrical and face one another, being bolted to the inner sides of the short sides of the frame; each pole-piece has a diameter of 14.7 cm., a length of 23.5 cm., and is provided with an axial bore, 12 mm. in diameter.

The windings of each pole-piece prepared with careful precision consist of six cylindrical coils, fitting over one another; the coils are separated from one another by water jackets, the water circulating through the brass jackets in a zig-zag. There are four layers of wire in each partial coil, and no layer is more than 6 mm. from one of the water jackets.

The copper wire used exclusively for the windings has a diameter of 2 mm., and as the continuous current supply of Dr. Svedberg's laboratory is at 450 volts, and as there are about 4,500 turns of wire of a resistance of 20 ohms, he can work with currents of 20 amperes. The whole magnet can be suspended by a hook.

The weight of the base is 102 kg., the frame weight is 262 kg., that of each pole-piece 10 kg., of the coils 115 kg. per pole, giving a total weight of about 600 kg. Transport is facilitated by having the magnetic system separable in six parts. The pole gap can be varied between 2 cm. and 8 cm., its diameter between 3 cm. and 14.7 cm.; with an air gap 2 cm. long, 3 cm. in diameter, a maximum field intensity of 21,500 gauss can be obtained. The construction of this electromagnet, which is illustrated in the *Annalen der Physik* of July 17th, 1917, is much simpler than that of the powerful magnets which Pierre Weiss and H. Du Bois use for their researches.—*Engineering.*



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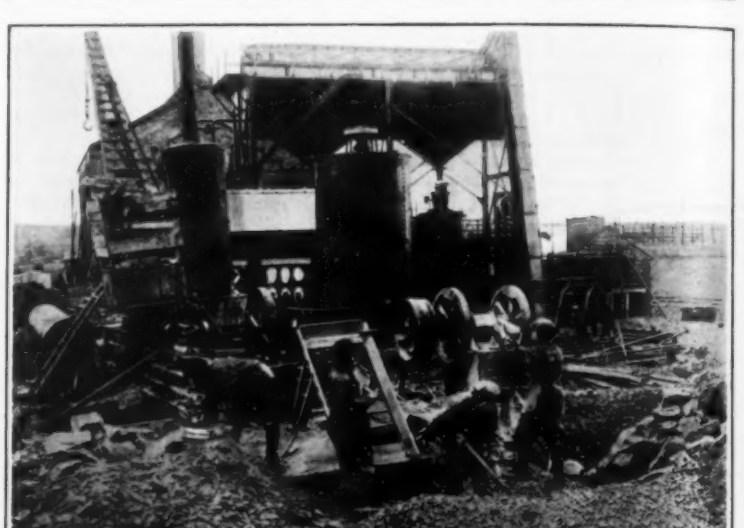
Women erecting a large water-tube boiler



Preparing concrete materials for concrete buildings

Women in Technical Work

One of the unexpected results of the war has been, as is now well known, the introduction of female labor in great quantities in machine shops, and many technical works for performing operations that women had not been considered qualified, or adapted for; but the withdrawal of great numbers of men, together with the urgent necessity for increased production, apparently left no choice in the matter.

At first the women were put on light work that called for little physical strength, such as the feeding of automatic machinery making light parts, and the operating of small drilling machines, the adjustment and care of the machines being attended to by experienced men; but gradually, as the pressure for labor increased, women have been employed in England for almost every description of manual labor, some of it being of a decidedly heavy character, as will be seen from the accompanying illustrations. It is not to be expected, however, that these conditions will continue after the war, for, although it may be in harmony with German ideas for women to dig in the fields and perform the rough work of excavation, shown in one of the pictures, this class of labor is not looked on with favor in more civilized countries.

In the lighter branches of work in the shops, however, there is every probability that women will continue to be employed permanently, for it has been found that they are particularly well qualified to perform operations where quickness of eye and hand, and delicacy of touch are required. And it is strange that this condition has not been more clearly recognized before, for they have been most successful in a number of branches of mechanical work for a number of years. An example of this is in the inspection and sorting of the hardened steel balls used for bearings, many thousands of which are handled in a large factory every day. In this work it has been found that women far excel male workers on account of their delicacy of touch and quickness of eye and hand, which enables them to detect imperfect pieces with great rapidity and accuracy. The inspection of small parts is another branch of work where it has been found that women do excellent work, for in many cases no particular mechanical knowledge is necessary, and after they have been instructed in the use of gages, and shown what constitute defects, the same qualities make them extremely useful. The stock rooms of manufacturing plants offer another field where women have proven themselves desirable, both for the reason that their innate instinct for order insures a more careful assorting of parts, thus eliminating errors, and because the women available for the work are much more intelligent than the class of men heretofore employed in such departments. In the tool room women have, for similar reasons, made a success.

Even before the war, when men were employed exclusively on mechanical operations, there were many classes of work where mechanical experience was not necessary, for the machines were "set up" by qualified assistant foremen, and any man of average intelligence could be taught to perform the required operation by a few hours of instruction. This was possible by the use of "jigs" and "fixtures," which are necessary for low cost quantity production, and which are universally used in every manufacturing establishment. In all such operations women are fully as competent as the class of men heretofore employed; and the only question is whether they can stand the strain of the continuous rapid production necessary. In this connection it is interesting to note that studies have been made in England on this point, and there seems to be reason to believe that, even in the case of men, long sustained effort on a single operation does not tend to efficient results. Possibly the solution of the problem will be the periodic shifting of the workers from one operation to another, to relieve the monotony of the movement.

After the war is over, undoubtedly women will be removed from the heavier descriptions of labor; and as work must be provided for the men as they return, a radical readjustment of the division of labor will be necessary.

Machining Versus Metal*

Problems To Be Solved by New Methods of Manufacture

The weight of all automotive machines, not even excepting the aeroplane, is very great by comparison with the load carried, and the weight which the machine itself possesses is dead weight that costs money to move and does no good. The only vehicle in which a rock bottom of lightness has apparently been reached is the pedal bicycle, which weighs about a sixth of its load, and by scientific design and costly workmanship it can be made 33 per cent lighter than the average.

The motorcycle weighs about 300 pounds and carries perhaps half its weight. The Ford car weighs nearly a ton and carries about a quarter of its own weight. A seven-passenger Marmon weighs 3,500 and carries less than a third of its weight. A five-ton truck weighs about the same as its load. From all these machines much could be cut if it did not cost so much to cut it. Even the Marmon, which is admittedly the lightest large car in the world, could be trimmed hundreds of pounds if drilling, filing and scraping were carried all over it, cutting off an ounce here and another there. Even in the Franklin there is some waste metal because of the prohibitive cost of removing it.

Neglecting cars in which weight reduction has been made a study, like the Marmon and Franklin, and turning to the conventional kind, the opportunities for weight cutting are increased enormously. The usual pressed steel frame can be cut out and drilled all over without weakening it, and still more weight saved by making it of a deeper lattice pattern, like the original Fergus frame. Cross members can be punched full of holes; spring hangers of steel forgings, machined all over, would weigh scarcely half as much as cast-steel parts. In an engine many pounds can be drilled out of a crankshaft without affecting its strength. Cylinders of thin steel, built up with the lathe and the welding outfit, may weigh less than a third as much as cast iron. Water pipes and manifolds could be pressed or drawn from aluminum of a quarter the weight of castings which do the work no better. Connecting-rods of alloy steel machined all over would remove another five pounds or so, while most of the bolts used could be hollow.

It may seem visionary to believe that the road vehicles of ten years hence will be much more like the aeroplane engines of today than like any other mechanism we know, but there is no reason why this should not come to pass. Press work is in only an early stage of development. High-speed machine tools are daily being rendered obsolete by still higher speed machines. The ability of automatic tools increases rapidly. Nor is it in machining only that changes are seen. Forging by dies is advancing as an art at a great pace, foundry practice is being modernized the world over, while the making of large parts from drawn steel is a new art that is scarcely born.

Looking back a short time and comparing then existing engineering with a cheap automobile of 1917, the latter would appear to be a marvel of lightness. Year by year we have found how to economize on metal, and we have so saved it because the more elaborate machining called for cost less than the metal saved.

Yet to the majority of automotive engineers the idea of working in close communion with machine tool, foundry, forging and other experts is strange. The production men and the engineers work with a river between them and seldom take the trouble to row across to the other side.

There is an opportunity for the S. A. E. to arrange some meetings for the discussion of new processes and new tools. It would encourage many an engineer to try out and help along some better way of doing things. The engineer always desires to economize material, the production expert to economize labor and cost. Development is only possible by experiment and experience. Is it not probable that the quantity manufacture of steel cylinders for the Liberty motor, for example, will show up new ways of making them vastly cheaper than any previous methods? Is it not possible that some way can be found to forge hollow crankshaft? Good ideas are so apt to languish for lack of interest, or lack of appreciation of the possibilities they hold. Such, for instance, is the process of hot rolling gears which makes almost a finished gear with no loss of metal whatever.

This instance happens to be one which has reached the writer's notice, but there must be many others. The point is that the engineer and manufacturer is too prone to wait till a new process is brought to him, and then to disbelieve it till some competitor has tried it out and proved its value.

*A. Ludlow Claydon in *The Automobile*.

Biochemistry of Plants

It has been shown that the heart-rot and dry-rot diseases of sugar beet and certain parasitic diseases of oats are in all probability due to the presence of alkaline substances in the soil in which they are grown. A garden soil which affected *Cyringa vulgaris* (lilac) was found to contain 0.88 grm. of water-soluble alkali per kilo. of dry soil. Roses grown in the same soil were greatly damaged by blight, although other plants *Lathyrus odoratus*, *Reseda*, *Trapæolum*, etc.) grew well. The affected roses recovered completely when peat dressing containing 16.6 grms. of acid (as H_2SO_4) per kiol. of air-dry material was applied. In a vineyard in which *Oidium* and *Perenospora* were very troublesome, the dried soil was found to contain 0.5 grm. of soluble alkali per kilo. On the other hand, the field thistle (*Cirsium arvense*) grew abundantly and vigorously in a soil containing 0.98 grm. of soluble alkali per kilo., and it is known that some plants grow best in acid soils. Investigations on the effect of the reaction of the soil on the growth of different species of plants and on plant parasites are urgently needed. The method used by the author for determining acid or alkaline substances in soils (see this J., 1915, 1064) consists in treating an aqueous extract of the soil with a solution of potassium iodide and iodate and titrating the liberated iodine with thiosulphate. If the extract is alkaline it is first treated with a known excess of standardized sulphuric acid; 1 c.c. of $N/100$ thiosulphate represents 0.00049 grm. of alkali.—*Journal of the Society of Chemical Industry.*

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Mixing concrete by hand for engineering work

Excavating preparatory to building operations

Evidence of Matter in Space Obstructing the Passage of Light*

By W. W. Campbell

Our photographic telescopes are confirming William Herschel's observation that the large and formless nebulæ are in or are bordered by regions of sky showing fewer stars than abound in the surrounding regions. The bright stars in the Pleiades, those really belonging to the cluster, are numerous, but within the cluster as we see it, and in a considerable area of the adjacent sky, the faint stars are markedly scarcer than in the areas farther away. Barnard has found that the sky in the region around the Pleiades group is possessed of much nebulosity. It is a natural question, are the faint stars scarce because the nebulosity there existing has not yet condensed into stellar forms? This may be true in part, but we shall find much more probable the view that the faint stars are deficient in numbers because the nebular materials, at a certain distance away from us, are obstructing the light of the faint stars that are farther away from us than the nebula is. A similar deficiency of faint stars exists within the great nebula of Orion, and likewise in the adjacent areas, where Mr. William H. Pickering has found a very large part of the constellation of Orion to be covered with faint nebulosity. There are so many regions in and near the galaxy where these relationships exist (that is, a presence of nebulosity and a scarcity of faint stars) that we can not doubt their significance. The faint stars are relatively scarce chiefly because the nebular materials cut off the light of the more distant stars. This explanation is reached by several lines of evidence, but we take time to present only one.

It is established by modern astronomy that the individual stars are in rapid motion. The speeds of the naked eye stars average about sixteen miles per second. The distant fainter stars, so far as they have been observed, are also traveling rapidly. There is a tendency to favor certain directions of motion, and the stars in certain small groups are keeping company through space; but a large share of stellar motion is at random. There are stars traveling in all directions. We have not the direct evidence as to the motions of the faint stars in the far distant outposts of the galaxy, but we have no reason to suspect that their characteristic motions are unique. We can see no escape from the condition that all the stars are in motion. Under these circumstances we are unable to explain how within a great volume of space that is rich in stars there can be a smaller, but still enormous volume of space, nearly free of stars. Their random motions should distribute them more uniformly than we observe to be the case. Let us illustrate by the celebrated black holes, the so-called "coal sacks," in the constellation of Sagittarius. In a region where the stars are especially plentiful are two small areas all but empty of visible stars. How can such great "holes" through the stellar system be surrounded by a plentitude of stars moving more or less at random so as to give a high density of star distribution right up to the sharply defined edges of the holes, and yet leave the holes empty of stars? With the help of all astronomical experience we can not explain the phenomena by the absence of stars. I think we must assume, with Barnard and others, that the stars are actually there, and that they are invisible because invisible materials between us and the stars are absorbing or occulting the light which the stars are trying to send us. Much of the interesting structure in the Milky Way is probably due in a like manner to obstruction by materials lying between us and the great clouds of stars. It is characteristic of the galactic structure that where luminous nebulæ seem to reduce the numbers of faint stars visible, the reduction in numbers of stars extends also far out beyond the limits of visible nebulosity, and we can scarcely resist the conclusion that invisible extensions of the luminous nebular fabric exist as obstructing agents.

There are many other lines of evidence in support of the hypothesis that invisible matter exists in abundance within the stellar system:

1. Newcomb and Kelvin, working independently and on the assumption that the motions of the stars are generated by gravitational attractions originating within the stellar system, were unable to account for the high observed velocities of stars, except on the hypothesis that the visible stars contain only a small fraction of the matter existing in the system; the greater part of the attracting material in the stellar system being non-luminous, or at least invisible.

2. There must be an enormous amount of comet material distributed throughout space. The astronomers discover only a negligibly small proportion of the comets which pass near the center of our solar system. May not comet materials exist also in abundance in the systems of the other stars?

3. Students of meteors have established that the separate little bodies which collide with the earth's atmosphere and are responsible for the so-called shooting stars are stupendous in numbers. It has been estimated that as many as twenty or thirty millions of such bodies collide with the earth every 24 hours. How incomparably and inconceivably greater must be the total number in our solar system. The power of these countless particles to obstruct the passage of light is not negligible. There may be as many such particles on the average around the other stars in our stellar system.

4. The so-called new stars, otherwise known as temporary stars, afford interesting evidence on this point. These are stars which suddenly flash out at points where previously no stars were known to exist; or, in a few cases, where a faint existing star has in a few days become immensely brighter. Twenty-nine such stars have been observed in the past three centuries, 19 of them since 1886 when the photographic dry plate was applied systematically to the mapping of the heavens, and 15 of the 19 are to the credit of the Harvard observers. This is an average of one new star in less than two years in the last three decades; and, as some of the fainter new stars undoubtedly come and go unseen, it is evident that they are by no means rare objects. Now all of the temporary stars except five appeared in the Milky Way, and four of the five exceptions are worthy of note. Two of the five appeared in well-known nebulæ; another was located close to the edge of a spiral nebula, and quite probably in a faint outlying part of it; a fourth was observed to have a nebulous halo about it; and the fifth was but meagerly and imperfectly observed. Keeping the story as short as possible, a temporary star is seemingly best explained on the theory that a dark or relatively dark star traveling rapidly through space has met with resistance, such as a great nebula or cloud of particles would afford. While passing through the cloud the star is in effect bombarded at high velocity by the resisting materials. The surface strata become heated, and the luminosity of the star increases rapidly. The new star of February, 1901, in Perseus afforded interesting testimony. Wolf, at Heidelberg, photographed in August an irregular nebulous object near the star. Ritchey's photograph of September showed extensive areas of nebulosity in all directions from the star. In October Perrine and Ritchey discovered that the nebular structure had apparently moved outward from the star. Going back to a March photograph, taken for a different purpose, Perrine found recorded upon it an irregular ring of nebulosity closely surrounding the star which was not visible on later photographs. The region seemed to be full of nebulosity not visible to us under normal conditions. The rushing of the dark star into and through this resisting medium made the star the brightest one in the northern sky for several days. The great wave of light going out from the star when at this maximum brightness traveled far enough in five weeks to fall upon non-luminous materials and made a ring of nebulosity visible by reflection. Continuing its progress, with a speed of 186,000 miles per second, the wave of light illuminated the material which Wolf photographed far away from the star in August, the material which Ritchy photographed still farther away in September, and the still more distant materials which Perrine and Ritchey photographed in October, November and in later months. We were able to see this material only as the very strong wave of light which left the star at maximum brightness made the material luminous in passing.

We can scarcely doubt, in view of all these facts, that there is a stupendous amount of obstructing material scattered throughout our stellar system. This may eventually be condensed into stars; but the point I wish to emphasize is that the material is there, and is evidently obstructing the passage of light. The efficiency of the obstructing material is, no doubt, the greater in the long dimensions of the system; in the direction of the Milky Way.

*From a presidental address to the Am Ass. for the Advancement of Science

Protection against Noise and Vibration

The problem resolves itself to protection against "air noises" and against "ground noises." Protection against air noises may be obtained by air-tight enclosures and by measures preventing bending oscillations in (or the propagation of oscillations from) the "soundproof" walls. If a body is able to communicate its oscillations to the ground, we have to consider "ground noises" which, according to the nature of the vibrations and materials concerned, may be propagated by compression waves, thrust waves, expansion waves, surface waves, or bending waves. Light and loosely packed material damps ground noises by propagating them with reduced velocity and intensity. Where applicable, narrow air-gaps round a machine are effective against surface waves. Otherwise, insulating material should be used which withstands large alterations in thickness without loss of elasticity. Curves in the original show the amplitude of vibrations set up in a floor by a motor running at various speeds, with and without the use of a buffer mat. In this particular case there were amplitude maxima at 1,350, 1,700 and 2,550 r.p.m., without the mat. With the latter, the amplitudes of these three maxima were changed from 0.025, 0.091 and 0.235 mm. to 0.031, 0.091 and 0.11 mm. respectively and the speeds at which they occurred were reduced to 1,340, 1,600 and 2,100 r.p.m. The amplitude of the principal vibration within this speed-range was much reduced by the use of a damping mat, but the change in position of the vibration-speed curve was such that at 2,500 r.p.m. the mat reduced the amplitude of vibration to one-quarter.—Note in Science Abstracts on an article by K. Hencky in *Die Naturwissenschaften*.

The Biological Aspects of Warfare*—III

Instincts and Restraints that Affect Human Relations

By Harry Campbell, M. D. Lond., F. R. C. P. Lond., Physician to the West-End Hospital for Nervous Diseases, London

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MEANS OF PREVENTING WARFARE

Whether the nations of the world will ever attain to sufficient wisdom to abandon warfare I forbear to prophesy. One cannot but hope that with advancing knowledge and clearer vision war will tend to die out, and that just as we in this country, after centuries of internecine fighting, were finally welded into a united people, so all the nations of the earth will some day be united into one great commonwealth. We are living in great times. Vast regions of the world are being opened up and developed with stupendous zeal; the exuberant output of inventions, such as the telephone, the automobile, the flying machine, and labor-saving machinery of all kinds, is profoundly modifying the conditions of life; intercourse between nations is becoming more and more intimate, added to which men are gaining an ever deeper insight into the laws of life; the elemental facts of evolution, of heredity, and of social science are beginning to make serious appeal to men's minds, and must before long be accepted as axiomatic truths pregnant with meaning as regards human welfare. The time is not far distant when children will be taught these truths as they were once taught their catechism, so that they will become part and parcel of the common mental equipment, and when this stage of general enlightenment is reached nations, it may be hoped, will find other ways of settling their disputes than by an appeal to the barbaric sanction of might.

When the unhappy Malvolio complained of the darkness of his cell, the fool's taunt was, "There is no darkness but ignorance." It was Malvolio's entire ignorance of the true situation which led him to think that his mistress had lost her heart to him, and in like manner it was the darkness of ignorance which is responsible for the present European cataclysm, ignorance alike of the elemental principles of sociology and current European politics. Does anyone for one moment suppose that the masses of the Central Empires would have entered upon the present struggle so light-heartedly if they had understood the actual situation as the author of "J'Accuse" *e. g.*, understands it? Or if they had realized that hundreds of thousands of their numbers were to be slaughtered and broken without any resultant advantage to the survivors? Again, was it not ignorance—tragic ignorance—on the part of their rulers which allowed them to force on the war? They miscalculated, they displayed stupidity—they lacked *enlightenment*. Had they *known* the forces they were stirring up against themselves, we may be quite sure they would not have been guilty of what must ever rank as one of the greatest crimes in history.

A factor which we may reasonably hope will tend to make wars less frequent is the growth of democracy. The trend of political development among the most enlightened nations is towards a moderate, sane Socialism—a system of government which, while giving individualism fair scope, shall tend to equalize the present social inequalities. The political power of the masses will then steadily increase, and provided they be properly educated they may safely be trusted to use their power wisely. And when the informed masses of the different nations are brought together through accredited leaders and are thus enabled to act coördinately, they, realizing how much they have to lose and how little to gain by warring against one another, may be expected to insist that international disputes shall be adjusted on lines of justice and common-sense.

Commercial competition constitutes an important cause of warfare; naturally each nation tends to do the best for itself commercially. Hence has arisen the pernicious system of tariffs by which each nation strives to encourage its own industries at the expense of those of other nations, and this artificial bolstering-up of home industries sets artificial boundaries between the nations and is a perennial source of jealousies, frictions, and quarrels. An infinite benefit would be conferred upon the world at large by a removal of these artificial barriers and by the adoption of free trade all round. Not only would this do away with the immense amount of delay and, inconvenience necessitated by the collection of duties; not only would it facilitate international intercourse and liberate armies of officials engaged in unproductive labor for employment profitable to the State, but, most important of all, it would remove what is perhaps the chief cause of warfare.

The establishment of a United States of Europe trading among themselves as do the United States of America, without any harassing restrictions, has surely been the dream of everyone who has thought seriously over the social future of the peoples of Europe. Under such a system each State should as far as possible be constituted with due regard to race, history, and popular vote; each should be allowed to govern itself in its own way without any unwise interruption of historical continuity or any undue breaking away from tradition, and no State should arrogate to itself precedence over any other. The fighting force of each State should be no larger than would suffice for the maintenance of internal order, and all plant for the manufacture of weapons other than those needful for this purpose should be scrapped. There would thus be an end of artillery—light and heavy—quick-firing guns, bombs, mines, and the like. The sole firearm remaining would be the rifle which, being used for sport, could not well be discarded. Needless to say that with these restrictions, aerial and submarine warfare would die a natural death, while warfare by sea and land, if it did occur, would be infinitely less disastrous than at present—though quite as efficacious. (I may remark by the way that aerial warfare bids fair to eliminate all other forms. What naval or military base could withstand the bombardment of 50,000 aeroplanes? Only subterranean chambers are safe from serious aerial attack.) Any breach of the covenant by a State, or any dispute between one State and another, should be referred to a supreme tribunal constituted of delegates from each State.

I am aware, of course, that at the present time such a scheme is purely visionary: it is but a dream, yet it is one that we may well strive to make a reality.

POSTSCRIPT

Considerations of space have prevented me from dealing with many aspects of my subject. One of these relates to fear. Is it not wonderful that so many millions of men are capable of mustering sufficient courage to face the terrors of modern warfare? Courage is an asset of inestimable value.

> Cowards die many times before their deaths;
> The valiant never taste of death but once.

We as medical men are familiar with the pathophobiac who pays us periodical visits in order to be assured that there is nothing the matter with him, and of the man who smilingly meets a lingering death from cancer of the larynx. One of the unhappy effects of modern warfare is that it tends to preserve the timid at the expense of the brave, thus lowering the racial level of courage. The brave man seeks out danger, the timid man avoids it, and there are many ways of evading dangerous service and of minimizing risks.

The liability to fear may be so great as to be pathological. One of this temperament is apt to become the victim of morbid fears—fears having no adequate objective cause. Claustrophobia is such a fear. I am led to refer to it here because the conditions of modern trench warfare are specially calculated to call it forth, and also because Dr. W. H. R. Rivers has recently related an interesting case of this disease in the pages of this journal.[1] My interest in claustrophobia was roused many years ago by a family of claustrophobiacs, and since then I have had the opportunity of studying several cases.

Those who display a constitutional morbid tendency to fear—the congenital phobiacs, as we may term them—constitute a definite class of psychasthenics. What particular form their fear, or fears, shall take depends very largely upon chance circumstances, but claustrophobia, like the fear of the dark and other instinctive fears, tends to be inherited as such, as I have several times observed. This morbid fear appears to be an exaggeration of a normal instinct—the dread of capture, or of anything which interferes with bodily freedom. It will be remembered that one of Lear's wicked daughters, in her endeavor to outbid her sisters for the father's goodwill, could think of no more precious possessions than "eyesight, *space* and *liberty*."

In the family referred to the father, several of the children, and some of the grandchildren have displayed well-marked claustrophobic tendencies, and I have satisfied myself that in each case the fear has arisen independently, and that mutual suggestion has played no part in the pathogenesis. One of the sons has not traveled for 30 years in a train; another son, at the age of 50, suddenly developed panic while traveling in the Tube, and has had to give up that mode of traveling.

I would take this opportunity of advancing two propositions bearing upon the pathogenesis and treatment of psychasthenia.

1. The essential feature of all the phobias met with in psychasthenia, and, indeed, of all forms of genuine psychasthenia, is a congenitally defective mental temperament—an abnormality in the realm of feeling tone. How far this depends upon defective cerebral organization (*e. g.*, of the paleo-thalamus, the probable center of feeling tone), or how far upon the composition of the blood plasma, need not now be considered.

2. Mental temperament is inborn, and but little susceptible of being altered. A person is born with a certain temperament for which he is no more responsible than for the shape of his nose, and this inborn temperament tends to remain fundamentally the same throughout life, resisting almost completely all attempts, educational or psycho-therapeutical, to modify it. No doubt some of his emotional disposition can be modified by training—an artistic aptitude can be developed by constant exercise, a bad temper bettered by systematic control—yet the native temperament remains, fundamentally unchanged. A person's temperament never in fact, undergoes a decided change except as the result of the normal cyclical changes, such as puberty and senility, or in consequence of disease, such as Graves's disease, myxœdema, or actual insanity. We meet a man we have not seen for years, and when we come to speak to him it is as if we were carrying on a conversation of yesterday, so conscious are we of his unaltered temperament; and it is this which constitutes the essence of the man, or, as we say, his personality. There are the same old gestures, the same old tricks of speech, the same old play of facial expression, all indicative of the same temperament. Contact with the world, his successes, his failures, his troubles, have no doubt left their impress. Youthful ardor may have been damped; the optimist may have lost some of his hopefulness; the shy man may have grown bolder; the genial man may have become somewhat soured, the cheery nature more subdued; but all such changes are on the surface only. When we come to probe below the surface we shall find that the temperament remains fundamentally the same: the very sensitive, the very shy, the very timid, the irrepressibly self-confident, remain sensitive, shy, timid, self-confident to the end of the chapter.

Now if the foregoing propositions are sound—if a congenitally morbid mental temperament constitutes the basis of classical psychasthenia, and if temperament is all but insusceptible of being changed—the limitations of psychotherapy in psychasthenia are apparent. If we cannot alter feeling tone, strike at the foundation upon which the whole superstructure of psychasthenia is built up, we cannot cure the affection. In my experience the congenital psychasthenic remains psychasthenic to the end. I am far from saying that psychic treatment is wholly useless for these patients. Much can be done to establish a sane habit of thought and to discipline morbid feeling tone, even though this remains essentially the same.

As to the legitimacy of the conclusions Dr. Rivers draws from his case I am somewhat doubtful. His patient, one judges from the description, appears to be a congenital psychasthenic with a bent towards claustrophobia. It is, of course, conceivable that but for the early claustrophobic incident the specific fear of closed spaces would never have displayed itself; but everything must have a beginning, and I judge that the experience with the dog happened to be the first opportunity for the display of the specific fear. Thereafter it showed itself on several occasions, and I suggest that these later manifestations would have occurred even in the absence of the initial incident.

My experience of claustrophobia leads me to doubt whether the mere resuscitation of a forgotten experience is capable of dispersing the fear. May not the cure (?) in Dr. River's case be an instance of faith-healing? Do we sufficiently realize the tremendous power of *absolute* belief? If we could convince a person that by jumping off the Monument in a particular way he would plane gently down and alight unhurt below, he would have no kind of hesitation in attempting the experiment. Similarly, if we succeed in implanting the belief that the revival of a forgotten fearful experience will for ever prevent the recurrence of a similar fear, we shall go far to prevent its recurrence. The crucial test would be to observe the effect of the revival without letting the patient know that a cure was expected from it.

*From *The Lancet*.

[1] *The Lancet*, 1917, II. p. 237.

A Problem of Wooden Shipbuilding*

The Preservation of Hulls

By Bror L. Grondal, Assistant Professor, College of Forestry, University of Washington, Seattle

A PROBLEM that offers more difficulties from the standpoint of wood preservation than the protection of the interior framing of wooden vessels, is the protection of the outer sheathing or planking of the hulls. The salt waters of the ocean, harbor a number of wood-destroying organisms that in some places make short work of unprotected wooden bottoms. These organisms are the molluscs known as ship-worms, commonly called xylotrya and teredo, and a number of crustaceans, the most destructive being the common limnoria. In addition to the problem of preventing the attacks of these, some means must be provided for preventing the accumulation of barnacles and seaweed, which materially affect the speed of a vessel. One of the earliest expedients adopted for this purpose was the charring of ships' bottoms. The planking was periodically charred to a depth of about a quarter of an inch with a slow fire. This was effective for only a few months, when it became necessary to again char the hull. Such charring resulted in the partial destructive distillation of the outermost portion of the wood, liberating small amounts of wood tar containing a high percentage of phenoloid bodies, which are highly distasteful to ship-worms. As these are, however, soluble in water, they soon leached out, leaving the wood unprotected. The charred surface also prevented the accumulation of barnacles, for as soon as a free-swimming larva attempted to attach itself to the charred surface, the charcoal, being very friable, would break loose, releasing the barnacle. The destruction of the wood due to repeated charrings makes this method impracticable.

Later the sheathing of bottoms with lead was attempted with only partial success, as it developed that the lead corroded very rapidly around the fastenings, and the adhesion of barnacles was not prevented. Iron sheathings were also found to be impracticable, due to rapid corrosion, though iron sheathings in the form of flat-headed nails driven so closely together that the subsequent rusting formed a complete coating of iron oxide are still used to a limited extent both for the protection of small ships' bottoms and piling exposed to the attacks of ship-worms. Zinc sheathing also failed to give satisfactory results, corroding very rapidly, possibly due to the galvanic action between the zinc and the fastenings used in attaching it to the hull. Copper and brass sheathings have proven to be by a considerable margin the best protection for ships' bottoms. Brass composed of from 50 per cent to 60 per cent of copper, alloyed with zinc, has given very satisfactory results. If the alloy is not complete, however, such sheathings will disintegrate very rapidly, as corrosion will spread very rapidly from the small nodules of zinc in the metal. Cold rolled furnace copper is the best of metal sheathings for the protection of ships' bottoms. As ship-worms cannot bore through metal, copper, of course, accomplishes its purpose in this regard. The most valuable property of copper, however, lies in the slow and very uniform corrosion of this metal. Though barnacles readily attach themselves to the metallic surface, they do not have time to reach their full development before the slow wasting of the copper loosens their attachment to the copper, compelling them to drop off. As a general thing, 20 to 30-gage sheet copper is used. The amount of copper sheathing per gross ton, of course, varies widely with the shape and size of the hull of the vessel, small boats requiring as much as 60 pounds of copper per gross ton.

At the present time the high cost of copper prohibits the use of this material in the sheathing of ships. The life of copper sheathing is at the best only from five to seven years, when it is necessary to renew the sheathing. The cost of copper has led to the development of substitutes in the form of paints which are applied directly to the surface of the wood. There are a number of different brands of paints for this purpose in the market. Some are positively useless, others accomplish their object to a satisfactory degree. The composition of such paint is invariably supposed to be a profound secret—and some of the secrets are truly laughable. One method of preventing the attacks of ship-worms, devised by one of the Anthony Comstocks of New York city in the early part of the nineteenth century (his name has been forgotten), consisted in pitching the hull with hot coal tar pitch, and before the pitch had hardened liberally sprinkling the surface with Scotch snuff. He reasoned that as tobacco was such iniquitous stuff, the ship-worms would surely be discouraged.

Some "copper" paints are, however, quite effective. The writer will not attempt to say which is the most effective. As the pigment of these paints is invariably copper oxide, they commonly are spoken of as "copper" paints. The nature of the vehicle varies widely, from linseed oil with a high percentage of linseed driers, to soya bean oil and kerosene. "Princess metallic" is very commonly used. Viewing the matter from an impartial standpoint, the writer feels that there is a tremendous waste of good copper oxide in marine paints. Whiting could be made to do very well, for the toxicity necessary to prevent the ingress of ship-worms can readily be supplied through the addition of small amounts of mercuric chloride, or such alkaloids as acridene. Aside from the toxic effect of the paint upon wood-borers, the basic principle in the manufacture of a successful "copper" paint seems to lie in the compounding of the paint in such a manner that the surface will slowly waste away, preventing the adhesion of barnacles and the seaweed which these will gather, and at the same time adhering properly to the wood. From the foregoing it becomes apparent why creosoting or the application of coal tar is not effective in the treatment of ships' bottoms. Either will prevent the ingress of ship-worms, but anyone who is familiar with the use of creosoted piling for dock construction will recall that such piling quickly becomes covered with a healthy growth of barnacles.

"Copper" paints, like all other paints, should only be applied to dry surfaces. In painting scows, tugs and other bottoms, the first or priming coat, which is applied after the seams have been properly caulked, is thinned with refined coal tar creosote or benzine in equal proportions, or one gallon of the paint to one gallon of the thinner. Care must be taken to cover the surface of the planking thoroughly before the painting is continued with a second coat. The caulking seams are then filled with a mixture of Portland cement and sand in the proportions of about three parts of cement to one part of sand. Some shipbuilding concerns make a special point of the use of only pure white silica sand in this connection, but the writer feels that this is unnecessary. Care should be taken to use fine sand, however, to enable the smooth troweling of the seam. The mortar is not allowed to completely fill the caulking seam, the point of the trowel being used to remove surplus mortar. When the mortar has thoroughly set, after the course of several days, surplus mortar that has slopped upon the surface of the planking is removed with coarse sandpaper. The hull is then ready for the second coat. While cement adheres very strongly to the caulking seam, its use is objectionable when it becomes necessary to re-caulk a seam, due to the difficulty of removing it, as in time it becomes almost flint hard.

The writer has experimented with a mastic for this purpose, composed of paving pitch, asphalt and wood pulp, thinned with engine distillate until it acquires a workable consistency, with seemingly favorable results. A definite statement cannot, however, be made at this time. Some ship owners require the first coat to be unthinned copper paint, though the necessity for this is disputed by some experienced shipbuilders.

After the seams have been cemented, the second coat of copper paint full strength, is applied. As these paints have approximately the consistency of ordinary paint, though in some cases they may be a little thicker, no difficulty is experienced in finding painters who are capable of doing the work.

After the second coat has dried for at least two days, the application of a third coat is necessary. As an example of the antique ideas that have survived since the earlier days of our shipbuilding industry, the writer regretfully cites the following requirement of one "expert" inspector who is supervising the construction of vessels for the Emergency Fleet Corporation at one of the Pacific Coast yards. This inspector has ruled that the third or final coat of paint shall not be applied to the hull until at least the day before the launching of the vessel; preferably the day on which the vessel is to be launched. The effect of such a procedure is, of course, bad in every respect, as the wet paint is washed from the surface of the wood, making the third coat quite useless. Rational practice demands that the final coat be given at least three days before the launching of the vessel, allowing at least time enough for the paint to set before the ship goes down the launching ways.

Formerly all copper paint was applied to the planking by the brush method. This method is almost entirely used in the smaller yards. On the Pacific Coast, however, the larger yards are using paint "guns," or sprayers which are operated by compressed air. With this method the paint is quickly and evenly applied to the surface of the wood, with a considerable saving in the labor cost of painting. Five good painters with brushes will cover the hull of a typical vessel about 250 feet long in one day. When the "gun" is used, two men will cover the same vessel in one day. Though some paint is, of course, lost when the "gun" is used—about 15 gallons in giving the above vessel three coats—this expense is more than compensated for by the saving in labor costs and the added convenience of the method. In spite of the fact that the paint is applied more evenly and thoroughly with the "gun," the same government inspector mentioned above has ruled against its use, demanding the painting by brush as in the "good old days."

In barrel lots, the cost of copper paint averages about $2.20 per gallon, and when used without thinning for three coats, one gallon will cover about one and one-fifth squares. By thinning the first coat with an equal quantity of thinner, one gallon of paint will cover approximately two squares.

Sea going vessels that have been properly painted with "copper" paints must be repainted at intervals varying from six to eight months. One company operating a large fleet of scows on Puget Sound reports the repainting of scow bottoms at intervals of 12 months. The first repainting must be done about six months after the vessel has been placed in service, as spots that are covered by the propping used in supporting the vessel during construction receive only one coat, which is applied immediately before launching after the vessel is safely resting in the launching cradle.

In conclusion, the writer wishes to emphasize the necessity of allowing each coat of paint to dry thoroughly before the next is applied. When properly applied, copper paint is an excellent substitute for copper sheathing, and where it is convenient to dock the vessel at intervals of from six to eight months, will give even superior service.

*From an article published in *The West Coast Lumberman*.

Phenomena of Electrolytic Migration

THE insertion of a diaphragm between the walls of a vessel containing a liquid undergoing electrolysis with electrodes which are not attacked, causes notable changes of concentration in the two compartments. A solution of potassium or sodium hydroxide thus becomes more concentrated at the negative pole, and more dilute at the positive pole, while the converse relationship is obtained with an acid. The change in the concentration is determined by the transport numbers or the relation between the migration velocities of anion and cation, and also by diffusion and electrical endosmose, which favor the migration of certain ions and retard those with an opposite electrical charge. The transport numbers are again affected by temperature, and the diffusion and cataphoresis effects vary with the potential and with the current density. With sodium hydroxide, cataphoresis and increase of temperature both hinder the migration of the hydroxyl ion relatively to the sodium ion, thus increasing the concentration in the catholyte. The current yield in regard to this concentration increases with the current density up to a certain limiting value, when further increase of current density gives a relatively lower yield. The most favorable intensity of current varies with the concentration of the electrolyte. With 2.5 amps., at 15 volts potential between the electrodes, in 865 c.c. of 0.775 *N* sodium hydroxide solution, and a temperature of 17.5 C., after passing 10 amp.-hrs., an increase of concentration corresponding to a current yield of 35.7 per cent was obtained. With an anolyte of sodium carbonate and a catholyte of sodium hydroxide a similar concentration of sodium hydroxide occurs at the cathode, while bicarbonate is formed at the anode and finally precipitates, and the resistance of the cell gradually increases and finally stops the electrolysis. By adding to the anolyte a soluble oxy-salt such as nitrate, sulphate, chlorate, or perchlorate, the increase of resistance can be avoided, while the migration of sodium ions to the catholyte is not hindered. In this way, at a temperature of 52° C., starting with an anode liquor of 3.3 *N* sodium hydroxide and a cathode liquor of saturated sodium carbonate, together with 100 grms. of sodium nitrate per litre, and a current of 10 amps. for 13 hours, a concentration of 11.3 *N* sodium hydroxide was obtained with a current yield of 42.6 per cent. This method of electrolytic concentration also enables pure baryta to be prepared from witherite ($BaCO_3$), used in conjunction with barium nitrate.—Note in *Journal of the Society of Chemical Industry* on a article by M. VAN LAER in J. *Chim. Phys.*

The Collocation of Plasmas Within the Cell—I*

A Survey of a Mechanical Theory of Heredity

By Dr. Louis Legrand

In spite of the title given above this article is not a revival of the simplist and multisecular belief in the collocation of germs. The fact is that science has made remarkable progress since the quarrel of the Ovists and the Spermatists was settled.

But since everything seems to have been said upon a subject which is so vast and has been so thoroughly investigated we necessarily come in contact with older theories which are chronologically superposed without having entirely disappeared, and far from having mutally destroyed each other, reciprocally support each other at certain points. It is also true that biologists can make here and there certain inevitable, through fragmentary approximations to the notable and sometimes classic ideas of Darwin, Brooks, Weissmann, Delage, Hallez, Hertwig, Naegeli and De Vries among others.

The peculiar innovation consists in an attempt at the figurative representation of the structure of the substances which we have come to believe are factors in heredity: such a diagram, intermediate between the mathematical graphic and the microscopic reality, should be sufficiently flexible to enable us to grasp at once the general and the particular, to adapt itself to the multiple tasks which the theory has in view, if we attempt in this overgrown thicket of biology "to explain the Visible Complicated by the simple Invisible," according to the desire of one of eminent physicists.

I—CELLULAR AND NUCLEAR PLASMAS

We take our start from the well-known descriptions of the cell and the nucleus aside from histologic formations (membrane, nuclein, centrosome, vacuoles, inclusions, leucites, pigments) which are neither universal nor permanent. The cell is constituted by somewhat hyaline plasmas, cytoplasma, in which is enclosed a rather limited, more refractive, more colorable nucleus formed of very analogous plasmas, nucleins or chromatines.

Although at the present time there is no single plasma of any given species whose chemical composition in the living state is completely known, yet we have data sufficient to enable us to form an idea of this constitution. If the cell is not exactly, as Pflueger said, "a giant molecule," yet its plasms are an assemblage of large molecules, all of which are known in the isolated state; they have nothing qualitatively specific, since they exist in both domains, they are of the order of the amid acids (leucine type, glycocolle) with the nucleic acid as the fundamental nucleus (Kossel and Matthews). The enzymes, for example, plasmatic fragments already voluminous, are a complex of molecules of the first order (lecithine type, albumoses, nucleo-proteids), to which are adjoined several groups of molecules of the second order (pentose types, xanthic bases, fatty acids, neurine). These voluminous compounds are in their turn united with each other by identical masses which repeat themselves a great number of times in a given protoplasm.[1] Just as in a mosaic of square tiles the same designs are repeated, formed of the same number of the same kind of cubes of colored stone at the same distance from each other, and in the same position.

This cell is of the average type, not too much differentiated, not too much denatured from the composition type by the functional specialization which gives preponderance to certain principles (glycogen, fats, zymases, mucus, protagons) at the expense of the albuminoids of the species; we can, therefore, make an abstraction of the types wherein such a "functional chemical constitution" surpasses and eclipses the specific zoologic constitution (for example, of the genre of the cytases of Besredka) common to all of the cells of the organism under consideration.

What is there then which is specific for the constituents of the cellular plasmas, for these substances so ubiquitous and so abundant, which chemistry discovers in slightly varying proportions in the humors of animals? There can be nothing specific except their number and particularly their method of reciprocal union, their mode of fixation to the principal neuclei whose accumulation by thousands produces a cytoplasm. The plasmas thus united with each other in the cell, during the life of the individual, merit the name of fixed plasmas, for this association is, by definition, correlative of the death of the cell, and if it is generalized throughout the soma it produces the death of the organism itself.

But fixation is not synonomous with crystalline rigidity, whether the large constituent molecules are sufficiently numerous for their displacements to accommodate themselves to the general movements of living, elastic, viscous and mobile plasmas, or whether this mobility remains compatible with certain temporary molecular "defixations," with automatic attachment without fundamental alteration of the structure of the whole; for the definite fragmentation coincides, of course, with cellular death with the liberation of numerous molecular links and with the appearance of coloring aptitudes unknown in life.

The nucleus has not a fundamentally different constitution. This central spheroid, which can be easily discerned in a living state without the artifice of coloration, is formed of nucleins closely resembling the vitellines (Tichomiroff), molecular blocks of the same order as those of the cytoplasm, but flanked by a larger proportion of metallic or metalloidic appendices in a more or less dissimulated condition.

We must give up the idea of considering nuclear and cellular plasmas as of opposite chemical constitution, and the process occurs according to Kolliker, Prennant, Carnoy, as if there existed an intergrowth of the plastic net works of the cytoplasm and the nucleus. It must be remembered, however, that these two substances are evidently not miscible, in the living and physiologic state, in the quiescent cell; moreover, Loeb and Carracido have noted the inversion of the signs of the electric charges of a nuclear substance and of the cytoplasm, as if it were a case of the inverse magnetization of the extremities of a single core wound about itself.

II—FIXED AND NON-FIXED CHARACTERS

The most superficial observation of heriditary forms and manifestations among living creatures, among the innumerable characteristics which may define the individual, and which are constantly transmitted, enables us to distinguish two sharply differentiated groups of very unequal importance. The first are the fixed characters which undergo no change as concerns two living creatures nor from one generation to the other; the four limbs and the hair in a mammal, retractile nails in carnivora, a single occipital condyle and feathers in a bird. These characteristics form the basis of classifications. They are subject to the laws of correlation and the more considerable the portion of the body of the animal which they concern the more unalterable they are. They are, therefore, multicellular, very rarely of the histologic order of the Metazoa. The tooth, which is at once a tissue and an organ, is a type of these much employed in classification. *The fixed characters are the specific characters.*

The others, those which change from one animal to another in the same species, or from one generation to the other, are *the non-fixed characters.* They are arranged in the following four classes:

1.—*The sex* and the secondary sexual characters.

2.—*The characters of the race* or of the variety. An example in the human species: the color of the skin, of the hair, of the iris, the pigment content of the epidermic cells, the form of the cross-section of the hairs, the cranial, nasal and maxillary indices which constitute the facial physiognomy of each race; steatopygia, the Mongolian blue spot; the average height and circumference; and finally the immense gamut of psychic aptitudes of each race; these are characters which were always transmitted when the consorts are of the same race.

3.—The third group, which is intermingled by insensible transitions with the preceding group, comprises characters which are strongly sporadic in the species, superficial and of minimum morphological importance, and which are irregularly transmitted. It concerns *ancestral* or *atavistic character;* it is rather their mode of appearance and of hereditary apportionment in lines of descent which merits this name than their peculiar value, for there is nothing to prevent them from becoming racial characters in time. They are often of a semi-pathologic or teratologic order. Examples: In the human species, baldness, sexdigitism, hemophilia and most of the diatheses compatible with fecundity; certain psychological characters, mathematical or musical aptitudes; facial features especially (the nose of the Bourbons) and a large number of external character which are delicate of estimation and difficult to express in figures, but which are very well known and appreciated by breeders and also in the human species (coarseness or fineness of extremities), etc.

4.—The last group comprises the almost infinite variety of the *individual characters of the immediate parents;* their transmission is sometimes very precise, sometimes entirely lacking. Their type is in the naevi, in the details, at times very minute, of the face or the body, in the quality of muscular and arterial tissues and of the glands; the majority of diatheses of lymphatism and the whole gamut of temperaments; the hemorrhagic diatheses, the neuroses, certain psychoses, longevity, sensorial qualities or defects, myopia, possibly Daltonism but not deaf-mutism. All the so-called family affections, especially when these are favored by consanguinity. This heredity can be pursued even into histologic details, as is indicated by the family resemblance in the arrangement of the papillae of the ends of the fingers so much utilized in anthropometry. This last group naturally involves all the pecliarities and accidents concerning which there is so much discussion as to whether they are susceptible of transmission as required characters.

The difference of importance between the fixed characters and the others is obvious; it makes little difference what causes a horse to be black or white, heavy built or rapid, a draught horse or a racer; it makes much difference what causes it to be a vertebrate, a quadruped, one of the herbivora, a soliped. What plasmas, therefore, will represent these two types of characters?

II.—FIXED AND NON-FIXED PLASMAS

LOCALIZATION AND VALUE

We have elsewhere defended the following opinion, which is moreover not absolutely new, that the fixed or specific characters, infinitely more numerous than the others, must be represented materially in organisms by an identical substance in all representatives of the Specific Plasma.[2] We have come to deny to any given specific plasma an elective localization in a particular tissue or organ, but to consider it as universally distributed in the only element common to all organisms and to all the parts of a given organism, *i. e.*, in the cell. This substance, forming the support of the most numerous and the most important characters, must preponderate also in material mass with relation to other plasmas which are the support of variable characters; it is principally for this reason that we have identified it approximately, and without the necessity of very great histologic precision, with the hyalin cytoplasm, nonspecialized and slightly chromophilous, of every living cell. Cytoplasm, therefore, is a synonym for fixed plasma, the material substratum of the fixed characters.

Another very important consideration is the following: These plasmatic blocks, histologically separate, which we call cells, are in reality "*fixed,*" the ones to the others, by their similar faces, by this substance identical with itself which is the cytoplasm; and this reciprocal fixation, which is very solid and fundamental in life, permits the existence of the tissues, the organs, and the *substances* of *all* the polyplastids. Hence, there is a flagrant antagonism, both histologic and biologic, between the cytoplasms, which are constantly fixed, the one to the other, and the nuclei which are never so fixed, which, in other words, are always defixed with relation to each other.

Moreover, the nuclear chromosomes, at certain crises of the cellular life, on the occasion of each cytodiaeresis, defix themselves even from the surrounding cytoplasm, after having undergone a series of transformations which makes them the type of the variable organs of the cell. *The chromatic apparatus, therefore, is constituted of non-fixed plasmas (fixed neither to each other nor to the cytoplasmic block), vehicles or material supports of non-fixed characters.*

And observe that these distinctions will find themselves amplified and rendered striking in the two cellular types most interesting from the point of view of Heredity, in the ovule and the spermatozoon.

Each specific plasma, the irreversible and almost immutable material substratum of the species, is found identical in all the living cells, but the necessities of the division of physiologic labor have caused it to accumulate with predilection and at times with prodigality in that

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*Revue Générale des Sciences.

[1] We are authorized to accept this repetition in particular by the consideration of the results of the experimental or physiologic fragmentation of certain ovules in which each fragment retains sufficient living substance to cause the development of a normal embryo.

[2] The idea of a plasma proper to each species is found here and there in the works of many modern biologists: Brooks, M. F. Guyer, C. H. Richet, Leduc, Le Dantec, Gautier, Dastre, E. B. Wilson, Lilie, Conklin, Fick, Loeb, Hallion, Benedikt. It has been made the subject moreover of a more profound investigation. (Legrand, The Selection of a Specific Plasma. Maloine, 1916.)

voluminous cell which we call the ripe ovule. It is formed evidently of old racial plasmas fixed and immobilized at their time in the course of the indefinitely prolonged life of a plant or animal phylum. But it is only artificially that we could think of dissociating it into its constituent elements, which form today, in substance and in mode of fixation, a perfect and definite amalgam.[3] The same molecular groups, chained to each other and to their neighbors, in a certain fashion which govern, in embryogenesis and then in ontogenesis, the

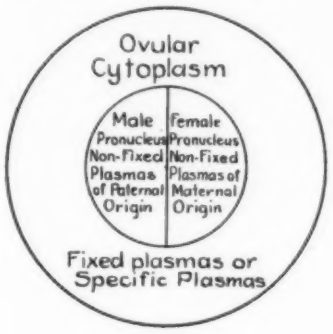
Ovular Cytoplasm
Male Pronucleus Non-Fixed Plasmas of Paternal Origin
Female Pronucleus Non-Fixed Plasmas of Maternal Origin
Fixed plasmas or Specific Plasmas

Fig. 1

nature of the dentition, the form of the condyles, the presence of retractile nails in the Carnivora Felidae, must be found in each ovule of this animal type, but they are never isolatedly dissociated in a viable being; and the study of certain organordal teratoma, or tumors with multiple tissues, shows us that if these monstrous productions succeed in developing they constantly retain the specific type as far as concerns the teeth, the hair, the skin, certain glands, the visceral fragments, without ever arriving at tissues or organs proper to a related or a non-related species.

It would certainly be very fine and most satisfactory to the mind it some unforeseeable artifice should permit the trace of the geologic ancestors of the animal studied to appear in this specific block, the organo formative relationships with groups extinct or near, but engaged in another evolutionary direction. This hope is not unrealizable theoretically, since certain easily discernible chemical affinities have been recognized between animals belonging to groups which one would have believed to be artificial (precipitins common to the Sauropsidae) and since the serum of living elephants is agglutinated by extracts from the congealed flesh of Siberian mammoths; but nothing authorizes us at the moment to hope to discover in these specific cytoplasms the traces of some molecular sedimentation or visible plasmatic imbrications corresponding to characters progressively acquired throughout the ages, characters of family, of class, of order, of branch.

Such is the idea which we are now permitted to form of the cytoplasm of the egg before fecundation.

This cytoplasm envelops and contains a nuclear mass, long since described, visible in the living state, which must represent materially *the four types* of non-fixed characters concerning the female bearing this ovule, her ascendants, and her race; physiologists are now agreed in considering this ovular chromatine as the plasmatic and dynamic equivalent of the spermatozoon, and this "homodynamics" (Weissmann) is the expression of this perception old as the Auman observation of the possible equality of influence of the two parents on the offspring.

And now what is the spermatozoon?

From the point of view which here interests us it can be given a definition which is at once very exact and very suggestive: *the spermatozoon* is the only living element now fixed to the soma; *i. e.*, susceptible of being separated from the soma and still remaining alive.

We are thus quite naturally led to behold in *the spermatozoon, for any given species, a principal or exclusive vehicle of the non-fixed plasmas,*[4] *i. e.*, that it must materially represent *the four types of non-fixed characters concerning the male from whom it emanated, his ascendants, and his race.*

[3] With the exception of the Hybrids, which we will consider later

[4] There is nothing absolute in this role, the result of the division of physiologic labor, which can be pushed more or less far. A complete review of the possible types of male gametes would commence with those which are the vehicles solely of the individual plasmas of the male (Brooks' theory), would base itself upon the ordinary type, vehicle of three plasmas, and would terminate with a less refined type, closer to any somatic cell whatever, incompletely lightened of cytoplasm, which would be sometimes distinct histologically from the spermatic chromatine (various appendices, undulating membranes), and sometimes indistinct. Since the tail, almost constant in the animal kingdom, is a cytoplasmic relic, we may say that every spermatozoon carries with it some more or less tenuous portion of the cytoplasmo. It is easy to perceive the importance of this for the mechanism of hybridization.

IV—THE STRATIFICATION OF PLASMAS IN THE AMPHIMIXIC CHROMATIN

Having thus stated this quite novel presentation of the isolated sexual elements, let us follow them in the course of cytologic fecundation and try to fathom the consequences.

The spermatozoon, obeying that positive chemitaxia which Delage has demonstrated to be peculiar to the cytoplasm of the egg, even after the expulsion of the female nucleus, penetrates the egg at a point on its

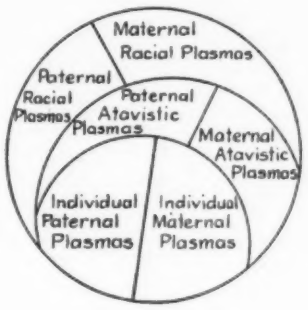

Fig. 2

surface which extends itself upon encountering it into a "cone of attraction," the histologic evidence of this chemitactic action: we know that this force is exerted at a certain distance and that two ripe eggs of different species, placed in a mixture of the fecundating fluids of their species, will, in a healthy condition, effect an exact selection of the spermatozoa which corresponds to them. The formation of the vitelline membrane and the cessation of the chemitactic attraction, constitute, immediately after this penetration, an ensemble of obstacles

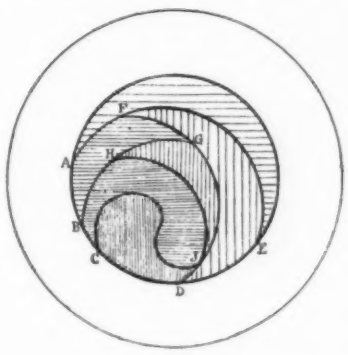

Fig. 4

which, in a healthy condition, opposes the entrance of another spermatozoon.

Neglecting at present the role of the Centrosomes (spermocenter and ovocenter) which is still a matter of controversy and has not certainly the generality attributed to it by H. Fol, there remains as a certain phenomenon the junction of the two pronuclei composed of the same number of chromosomes, at the center of the egg or very near that center, the male element having traversed the cytoplasm throughout its thickness.

The cytologic amphimixia is accomplished.

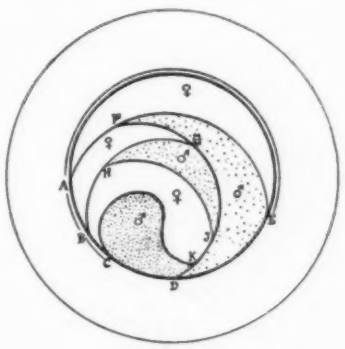

Fig. 5

We are now in the presence of a specific block within which are included: A small block of non-fixed plasmas of maternal origin, and joined to this the small block of non-fixed plasmas of paternal origin, the remainder of the head or chromatin of the spermatozoon.

Such a *plasmatic tread, in which each component possesses at the beginning its own individuality and its own material limits,* and recovers them, if it loses them at certain moments of the cellular life, then becoming again

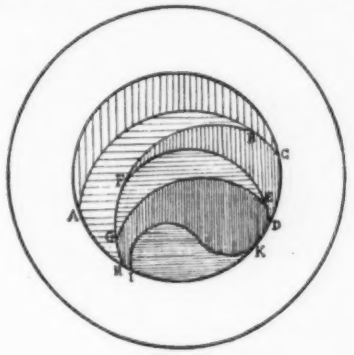

Fig. 3

distinct from the two others,[5] merits the name of *original trinitary block* (Fig. 1). We remark that it agglomerates together a great mass of plasmas fixed during the whole life of the individual and of the species, with two small masses of plasmas which are non-fixed during the life of the species, but which we must believe to be thenceforward fixed (physiologically if not histologically) during the life of the individual;[6] the indispensable postulate consists in admitting that those plasmas tend to resume their original mode of fixation with respect to the two other plasmatic blocks, every time that they are deranged, displaced, defixed, *i. e.*, in the course of each of the ulterior karyokinetic crises, universal factors of all embryogenesis and of all morphogenesis among the polyplastids.

These plasmatic masses of different origin which have arrived in contact in the common nucleus (nucleus of segmentation), cannot arrange themselves by chance; they must mutually arrange themselves, starting with the concave surface enveloping the specific cytoplasm in a certain order, of which figure 2 gives an approximate idea, and this order will probably be the age of the fixation with respect to this ancient plasma, the plasmas of more recent acquisition being the most central, and the racial plasmas the most peripheral, and occupying the largest surface of fixation with the specific enveloping block.

Moreover, there occurs, literally, a reciprocal arrangement of plasmas of the same age, of the same dynamic value, of the same ancientness proceeding from each genitor, the paternal racial plasmas joining with the maternal racial plasmas, the paternal atavistic plasmas with the maternal atavistic plasmas, with the paternal individual plasmas with the maternal individual plasmas.

But this figure is too diagrammatic. It does not indicate that we are dealing here particularly with plastic substances, movable with respect to each other, and subjected to reciprocal excentric and concentric pressures. In reality the plastic cap-shaped areas of the P. R. (racial plasma) and the P. At. (atavistic plasma), of each sex are not squarely in contact, but narrowed at the edges and overlapping in the manner of a plant bulb, at times, indeed, overlapping to such an extent as to become enveloping. And, if it is true, as we are taught by the history of the development and the peculiarities of heredity, that each non-fixed character preserves its individuality in the product until the end of growth, then the corresponding plasmas must preserve it also in the composite chromatines after the first, that of the egg, which we will describe presently: it is necessary then that, for example, the paternal racial plasmas should overlap the maternal racial plasmas, or inversely; it is necessary that the maternal atavistic plasmas should overlap the paternal atavistic plasmas, or inversely, as indicated in Figs. 3 and 4 where the plasmas of each sex are imbricated alternately, those of male origin cross-hatched vertically, those of female origin horizontally.

By according to these different plasmas minute differences of density, of miscibility, of mobility, we can easily succeed in imagining the reciprocal collocation of these caps, segments of an irregular spheroid with curved surfaces, the oldest crowded up towards the surrounding specific plasma, enveloping the more recent as an acquisition or as a facility of fixation to the total block. This is the collocation of plasmas, far more fruitful as an explanatory value than the collocation of germs, since it enables us to enclose the whole hereditary substratum in a small number of material figures, which we can, if not directly behold, at least identify, as colorable, meas-

[5] According to De Vries the fusion of the male and female substances is never complete: it may even be very imperfect, as in the *Cyclops* or the *Crepidula*, in which the nuclei present, during a large part of the somatic existence, a precise separation of the paternal and maternal substances.

[6] The fixation in their position of the plasmas, after the penetration of the spermatozoon, depends upon the well-known law of W. Roux, O. Schultze, Brachet, that the plane of penetration of the spermatozoon in the egg governs the first plane of segmentation and determines the plane of symmetry of the blastula.

urable, delimited plasmatic masses, which have hitherto remained without precise biologic signification, without specific affectation to the transfer of any given character.

V.—LATENT CHARACTERS

Still continuing to follow the logical exploitation of the sole directing postulate of the whole present theory, we must now admit that what matters from the viewpoint of the proportional part of the racial, atavistic, or individual plasmas transmitted by each genitor, is, in the

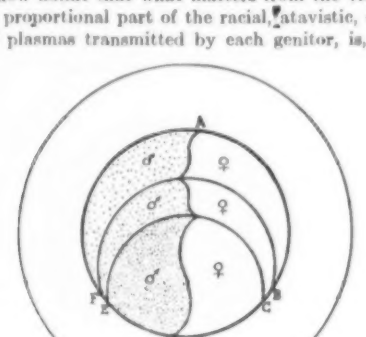

Fig. 6

diagram, as in reality, *the extent of the surface of contact and therefore of fixation of each of these plasmatic blocks with the envelope of fixed plasmas:* whence there results for them an order of involution and of evolution and order of complication of *plasmatic planes,* and by consequence—in a certain measure—an order of appearance of corresponding characters, and also by consequence an eclipse, an inhibition of the characters whose vehicles are the plasmas which have remained in the interior or at the free extremity of the filament.

This is the entirely simple explanation of how characters may be latent and yet transmitted: it is because their vector plasmas are, themselves, not latent; there are no plasmas latent, but without contact, or separated from the zone of adhesion, from the deep-rooted and active zone which separates or unites the fixed plasmas and the non-fixed plasmas, from that "historic" zone, from that zone of manifestation which thenceforth governs the relations of the cytoplasm and the nucleus, these plasmas have no dynamic value in the ontogenesis of the product at present under consideration. Thus, at the origin of every creature, a very important portion of the plasmas can be effectively transmitted, yet plays no part in the morphogenesis because it is not involved in the zone of fixation. But these plasmas are only momentarily "defixed" and may become again fixable and active in an ulterior amphimixis. Thus must be solved the celebrated apparent antinomy of a genitor transmitting to his descendants characters which he himself does not bear.

VI. THE PLASMATIC COLLOCATIONS AND THE MANIFESTATION OF CHARACTERS

If we consider the large surface of contact of the racial plasmas, their expansion into a vast enveloping cap, we must admit that of all the non-fixed characters it is these which are most numerous and which appear most constantly. It is doubtless this which happens, in fact, and if the genitors are of the same race these racial characters will all be present, being pushed into the active zone by one or the other of the identical masses of each sex. Consider for example the great extent of the useful surface which they occcupy in Fig. 3, adding the zone of maternal origin A H to the large semicircle A C provided by the paternal plasmas.

If they are not of the same race there will be a mixture of characters of the two races with every known proportion of hybridization.

Next in importance and frequency of transmission to the racial characters come the individual paternal and maternal characters. Here the very extended maternal plasmas in I K overlap the two modest extensions H I and K D of the paternal individual plasmas: whence comes the proportional predominance of the maternal resemblances.

Finally, in the last case, and more rarely, even to the extent of sometimes passing for biologic curiosities, the atavistic characters may possibly come to the front and almost constantly attach themselves to one of the ancestral sides to the exclusion of the other, as is a commonly observed fact in families. These characters will be manifest in small numbers when the edge of one of the intercalary caps whi h bear them, compressed between the two preceding plasmas, begins to come in contact with some part of the specific block and adhers to it by a few points which are necessarily very limited. In this case the maternal atavistic characters are eclipsed, inoperative, the block G F E being completely enclosed, while the atavistic characters on the paternal side will be of some importance thanks to the zone of adhesion of the block F B C D to the block C D.

The fecundated ovule of the opposite type will therefore determine for the individual which is born from it the following hereditary characters, taking into account for the sake of ease of description only the linear relations of the figure and not the real relations of the curved surfaces of which these lines are the projections:

1.—The enormous predominance of the paternal racial plasmas in the ratio five to one, the ratio between the

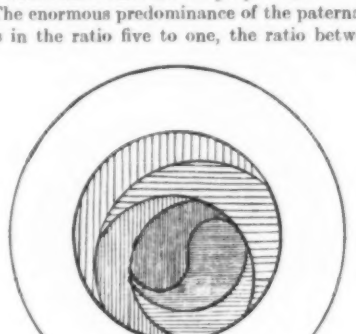

Fig. 7

zone of fixation A C and the zone A H. This will be of no importance unless the parents are of different races or varieties.

2.—No ancestral character on the maternal side: but these characters though latent and eclipsed in this individual may reappear in one of its offspring; a few atavistic characters of the paternal branch.

3.—A few individual characters of the father lost in a mass of maternal characters three or four times as important.

Suppose, for example, that the meeting of the two

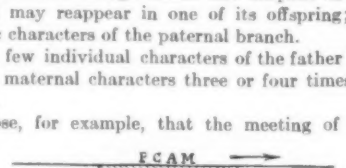

Fig. 9

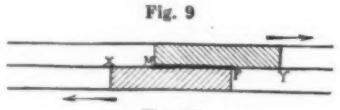

Fig. 10

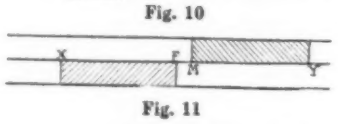

Fig. 11

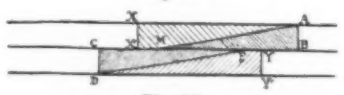

Fig. 12

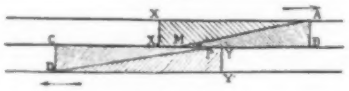

Fig. 13

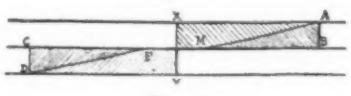

Fig. 14

chromatines is produced under a slightly different angle; it might have given rise to an amphimixic plasmatic type in which the enlacement of the homologous plasmas is totally rearranged with respect to the preceding, like that shown in diagram in Fig. 4, in which the plasmatic contacts are almost everywhere the inverse of those in Fig. 3. It concerns, however, two fecundated ovules of the same species, of the human ovules, if you like. Compare the extent of the lines, the nature of the curves, the importance of the surfaces, the points of contact, the zones of coincidence of two surfaces, or of the two lines which represent them—everything has been changed. A type of plastic architecture of this kind is made so definite, and by so many points and surfaces, that it may be considered as unique among millions and millions of possible combinations. In this ideal section of the egg, which is a plane, that of the figure, the simple broken line composed of the curves A F, G H, H J, J C, if we take into account the respective distances of each point, already possesses a marked individuality and it would be singularly rash to hope to find by chance one exactly similar; and we must not forget that all these slidings, adhesions, and fixations operate not merely in one plane, but in the three dimensions of space, between material spherical caps of a given thickness, dimension and curvature; and that naturally these caps are not limited to the diagrammatic number of five or six, but are superposed upon each other in great numbers, by hundreds or possibly by thousands. The biologist most difficult to convince ought to recognize therefore, when he recalls the complexity and the precision of the chemical structure of living substance, that we have here, not an improvised explanatory artifice, but a graphic representation of an infinitely complicated real, plasmatic structure capable of condensing characters into an infinitely small volume, that is, the possibilities of evolution of all the

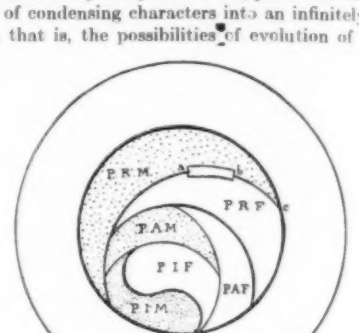

Fig. 8

somatic cells to be born from this one, not by thousands but by millions. But we must not forget that we need explain and support only the non-fixed characters, or rather the action of these plasmas and characters upon the block of fixed plasmas and characters, and more precisely *the morphologic modulations which the presence of these non-fixed characters impresses upon the ensemble of the fixed characters:* it will suffice, then, to endow first the blastomers, then the embryonic cells derived from them, then all the cells of the body with the same structural characters in order for the ontogenesis to evolve smoothly, automatically, and with the great precision which is at times observed with respect to all possible heritable characters, without any exception.

Let us now consider the male chromatine making its perforation through the cytoplasma's corticality; let us appreciate its highly effective, infinitesimal but real mechanical "action," for if it is not measurable in human processes, none the less does it have enormous biologic consequences after it has succeeded in inciting the equivalent "reaction" on the part of the female chromatine; for if the rebound of this impulse does not entail the release of a whole cosmogony in the Cartesian manner, at any rate it is the point of departure of an embryogenesis, possibly of a human life, with all its possible consequences from the point of view of Race and Species.

It is easy to perceive, moreover, that the point of penetration of the spermatozoon into the ovule, and the molecular state in which it surprises the quiescent female plasmas, may also be of great importance for the future of the new creature.

As soon as this accommodation between the various plasmatic planes has been accomplished, there is a period of repose well known to cytologists, and of fixation in this state of mechanical and physico-chemical equilibrium. And now we have defined a certain molecular structure peculiar to the new creature to come, and to it alone. We could draw on paper the extremely enlarged geometric outline diagram by taking account of its projection on successive planes. And it is this microplasm of multiple, spheroidal segments of planes and of curves with infinitely varied intersections, which will remain fixed in this state, insofar as the laws of Chemistry permit.

Finally, in the gametes issued from a new individual, these plasmas may again become "defixed," (after the kineses of maturation, for example); but, supposing that this arrangement be maintained throughout the individual somatic life until the mature genital elements be arrived at, the amphimixic shock to come will more or less upset this texture and these reciprocal relations of the P. N. F., relations which are thus made doubtful again, and must be resumed under a new type at each new amphimixia in the course of the specific life.

Observe that the present theory does not necessitate the addition of any substance whatever to the block of fixed plasmas and especially to the individual plasmas of each generation; but neither is there any impossibility that there may occur at certain moments of the specific life this extra or substitutive addition (mutation, saltation). And this marks the difference in the doctrine of the collocation of germs, which not being able to avoid the necessity of a substantial increase in each generation, demands in a very short time gametes of both sexes of the most improbable amounts.

The substance is given: it is sustained by the assimilative digestive synthesis; it is common, at time super-

abundant, and common to such a point that there is no simple or composite body of low molecular weight which can be strictly specific; and the little that we know of the human plasmas authorizes us to believe that it is very similar to the plasmas of animals upon which it is nourished.

What is specific, is the intimate, molecular, molar, filamentary architecture of these plasmas; and that is not merely specific, but it is also racial, atavistic and individual; it is even older than the species, it belongs to the order, to the class, to the branch. The whole future individual has his outline "diagram" sketched, systematized in this lowest protoplasmic sphere which the histologist can harden, dissect, and observe. But it is not a reduction of the corporeal form; it is useless to seek in it, as did Dalempatius and the first microscopists, a head and limbs: it is not a homunculus.

It is an abstraction, an idea.

It is hardly more material than a soul.

These are the geometric relations of a complication which is prodigious, but definite, fixed, almost immutable for this particular ovule, to the exclusion of every other in the entire universe, past or future. These are the possible planes of orientation, of directives for future cellular genesis, on condition that the specific plasma be furnished, continually and with entire purity, first by the mother, then by the selective, alimentary, autonomous synthesis during the remainder of growth.

VII—TRANSMISSION OF SEX

Of all the non-fixed characters, sex, with the secondary sexual characters, is the oldest, the most expressive, the one most generalized in the organism. It dominates all the others and impresses upon them something of one or another of its tonalities. Its position, therefore, must be somewhere on this concave spheroidal plane of the union and disunion of the fixed and the non-fixed plasmas; it envelops these and limits them towards the specific block, to which it has itself adhered from the remotest antiquity, for sex and the sexual characters are for the major part of specific order; but, since all the non-fixed characters, whether racial, atavistic, or paternal, are both paternal and maternal in origin, sex is also welded to their block and inseparable from it. We are familiar, for example, with the malformations of the epispadic or hypospadic meatus, and of the cryptorchidism. The secondary sexual characters (variation of the beard in man, of the crest and spur in the Gallinacea) may depend equally upon these three plasmatic origins.

Consider Fig. 5 a little after the amphimixic shock: for it is this which has just determined the sex of the offspring as can be readily perceived.

Under its influence the plasmatic caps are interlaced and arranged, those of paternal origin (dotted), rather towards the right hand and the bottom, those of maternal origin towards the left hand and the top. But we know that all these non-fixed plasmas whatever their nature and their origin, are also vehicles of sexual characters; and since it concerns characters reciprocally exclusive of each other, it is therefore the sex which, *by the totalization of the surfaces of fixation of its plasmas repesentative of the specific block*, will have the greatest extent of adhesions it is this which will have an ascendency over the other. Here it is the female sex, since E A + A B+B C> C D+D E; and the real proportion is very much greater than the plane figure indicates, since in reality it concerns the collocated spheroidal segments and complete spheroids.

The sex, therefore, is determined by that one of the two composite blocks which has literally "gotten the upper hand" with respect to the homologous and homodynamic plasmas of the other, which enters, therefore, from this point of view, into the general case of latent characters.

Observe that if the least sliding of the plasmatic caps in one direction or the other has its consequence in the transfer of ordinary characters, this does not hold true for the sexual characters, and the arrangement of plasmatic planes which determines sex is something as primordial and irreversible as the paging of a printed, folded, and numbered book.

See how, in spite of the evident homodynamics of the plasmas of each sex, this mode of covering, of effacing, this eclipse of the plasmas of one sex by those of the other accounts for the ulterior automatic development of the qualities proper to the sex of the enveloping plasma. Moreover, one need only enlarge as much as one wishes one of the caps with respect to the other to represent the material basis of the morphologic differences, so curious and sometimes so striking, which exist between the two sexes throughout the whole extent of the animal kingdom.

The egg type of Fig. 5 also enables us to comprehend another celebrated antinomy very simply solved by the present theory, that of the offspring resembling solely, or almost solely, one of its parents, while having the sex of the other. In this case it is a female (E A = A B = B C > C D = D E) which has as maternal characters only those represented by a trifling adhesion in B C; it will strongly resemble its father, on the contrary, by reason of the large surface of contact of the individual paternal plasmas in C D.

The rarity or impossibility of true hermaphroditism in the higher animals is explained by the extreme improbability of a precisely equilibrated partition of the plasmas of each sex; thus the type represented by Fig. 6, wherein the segment of fixation A B C D is perceptibly equal to the segment A F E D, has infinitely few chances of being realized subsequent to the amphimixic shock and one even perceives in A an inevitable plasmatic projection of the segment $\frac{1}{\delta}$ upon the segment $\frac{2}{\delta}$, which distributed would suffice to turn the scale and decide the appearance of the male sex.

VIII—OSCILLATING SPECIES

Our diagram of the fecundated egg adapts itself with great flexibility to the exceptional cases which biology may be called on to explain. Below is one of these taken as an example among many others which the plane of this article does not permit us to enumerate systemmatically.

It is the case (Fig. 7), wherein the individual characters of the genitors are never transmitted, the corresponding plasmas, because of density or for some other reason, not being able to come in contact with the specific block at any point. Such species oscillate indefinitely around a single type or a very small series of types. The individuals strangely resemble each other.

These species stand apart from all mutation and all progress until the moment when these innovation plasmas, which until now have remained inactive and impotent come, under one influence or another (increase of their volume or their density), to take their place, their surface of contact with the zone of manifestation, the historic zone of the species, and to play their contributory part to the morphology of individuals.

IX—APPLICATION TO A CONCRETE CASE; HEREDITY IN THE COLORATION OF THE FUR IN MICE

The biometricians have taught us that there exist in mice unit characters, each of which corresponds, in the Weissmanian "germinative plasma," to a determinant capable of independent variation; but the concrete descriptive character may be in relation with one or more determinants which can be made evident only by well directed crossings.

The present theory should be able to demonstrate how the internal relations of these characters can be simplified: by the reciprocal play of plasmatic material masses we shall be enabled to substitute for some of them others which are more comprehensive, and to bring out the true nature of certain abstract characters, the creation of human nomenclatures of which no plasma could be the vehicle.

By limiting ourselves to that which has reference to the determinants of color, which are at once rather complicated yet quite measurable, we shall be able to form an idea of the advantage to be derived from the theory with respect to simple cases.

From this point of view Cuénot has recognized in mice the independent existence of the following determinants:

1.—A determinant of the general color C, which exists in all pigmented mice (and perhaps in all the pigmented Vertebrata).

2.—Its mutation A corresponds to the absolute deprivation of color (Albinism), whatever be the other determinants of the hereditary formula.

3.—A determinant M, which accompanied by C is in proportion with the black color of the eyes; its mutation E corresponds to the red color of the eyes and lightens the general tint.

4.—In the presence of C there are three special determinants of color; yellow J, gray G, and black N, the first dominating the second, which dominates the last.

5.—U is a determinant of the uniform coloration of the fur, whatever be its tint; it is capable of a mutation P, which represents a more or less extensive streaking.

Let us now represent the possible arrangement of these plasmas. It is a case of non-fixed plasmas which are racial, or ancestral, preferably racial. Dissociating in imagination one of the spheroidal segments of the plasmatic masses constituting the amphimixic chromatine, we obtain a filament comparable to one of those chromatic filaments which the miscroscope has enabled us to recognize, and we must admit that what we have before us is precisely the vector filament of chromatic characters for the fur of mice.[7]

There are two cylindroidal plasmatic masses very similar in quality and in dimensions in the filamental segment furnished by each sex after the amphimixis. We may therefore give the name of amphimixic chromophoric plasma to each of these masses P C A M, P C A F, (Fig. 9) which may, and even must, remain in effective continuity with other formative plasmas X M, X F, not endowed with chromophore qualities, whose presence bears no relation to the transmission of pigmentation. These mobile filamental segments slide over each other during the period of gropings and arrangement following the shock of the male and female chromatines, yet seek, nevertheless, to attach and fix themselves to one another, in virtue of the reciprocal attraction of the homologous plasmas, which has been accepted as a highly probable postulate dominating all the amphimixic mechanism.

We have supposed, moreover, that the couple of the two filaments is in a suitable situation with respect to an adjacent zone of the specific plasma of this zone of manifestation which permits the characters to escape from the latent condition. But since we are concerned, in the example chosen, with racial characters exclusive of each other by couples, it is necessary besides, in order for the character studied to have all its value, all its plenitude, that it should establish a certain extent of adhesions between the two homologous plasmatic segments of each sex.

It suffices, therefore, to make one of the two plasmatic ribbons slide over the other in order to observe the various positions capable of translation into the characters of the product.

Fig. 9 presents the maximum adhesion, *i.e.*, the total of the amphimixic chromophore plasmas P C A M and P C A F; no adhesion with the adjacent non-chromophore plasmas X M, X F; *i. e.*, which one must by exclusion, consider as determinants of the white color or color of depigmented tissues. It concerns, therefore, the maximum pigmentation for the mouse studied. If we take it that the chromophore segment in question is the vehicle of black N, this simple figure gives us at a single stroke, the explanation of the three determinants:

1.—Determinant C, color in general, human concept, an abstraction without corresponding vector plasma.

2.—Determinant N, black color, with a corresponding plasmatic segment in the chromosomes.

3—Determinant U, uniformity of fur, human concept, abstraction without special vector plasma, yet represented, nevertheless, by something material, the total adhesion and fixation of the homologous plasmas N, which must tend to reproduce themselves, perhaps in all the blastomeres, perhaps in all the cells of the body, but surely in all the ectodermic line, whence issue the epidermic epitheliums and the colored hairs. Another type: Before the fixation has become definite the plasmastic ribbons have slipped over each other in opposite directions (Fig. 10) as the arrows indicate. They have stopped at the position determined by X M—F Y: *i. e.*, the average adhesion in M F between the chromophore plasmas; considerable adhesions in X M and F Y with adjacent non-chromophore plasmas. New result: Streaking, *i. e.*, mutation P of determinant U.

Intervention of three determinants: C, N, P (the latter exclusive of U).

Another type: In spite of the attraction of the homologous plasmas, the sliding in the direction of the arrows is accentuated. There is no longer any contact or fixation between the chromophore plasmas, which lose their hereditary dynamic values, which apparently cease to exist, and which become the bearers of latent characters (Fig. 11).

Definite adhesions establish themselves in X F, M Y, with any non-chromophore plasmas whatever.

Result: Absence of pigmentation. Albinism Intervention of four determinants, C, N, U, A. C, U, A, are always abstractions, without possible corresponding plasma; and observe that N, which is alone in possessing a material substratum, loses all hereditary value by this simple exaggerated gliding of a few fractions of a micron.

And the theory, far from claiming for albinism a corresponding and supernumerary particle, not only economizes it, but unexpectedly lightens it in its ensemble, since it succeeds by the same stroke in relegating albinism to the domain of abstractions.

X—PLASMAS AND DETERMINANTS JOINED BY COUPLES OR BY GROUPS

Every one knows that among living creatures certain

[7] It is very easy to localize this filament upon any spheroid whatever of the block of non-fixed characters: Upon figure 8, for example, this filament will be an element *A B* situated on the zone of contact of the male racial plasmas (dotted segment) with the corresponding female racial plasmas. A plane figure does not permit us to represent at the same time their common adhesion to the surrounding specific plasma, which does not seem to occur except at the point *c;* in reality, since it concerns spheroidal caps, this necessary triple intersection is pursued along a curved line projected somewhere in front of the plane of the figure and which can easily be reestablished in imagination.

This observation is valid for all the diagrams of the nuclear spheroid utilized in the course of this article.

characters are very closely united, manifesting themselves or failing to do so, together; all the specific characters behave in this way; a horned mammal does not have retractile nails, and a mammal with retractile nails is never horned.

The present theory, naturally, will furnish a convenient representation with regard to the non-fixed characters, which derives from the preceding paragraph and completes it.

Take the two plasmatic ribbons of cylindrical segment and triangular section M A B, F C D (Fig. 12), constituting a distinct part of the total chromophore *bâtonnets* X X^1, A B, Y Y^1 C D. These two elements are joined together materially, as the characters they represent are united solidly in ontogenesis. Let us attribute as a determinant to this triangular sector the production of the black pigment of the eyes. The extent of its adhesions with the corresponding homodynamic sector will give the following results, the sliding occurring in the direction of the arrows:

1.—If the movement stops at the stage of Fig. 12, simultaneously and conjointly, and important adhesion in M F, will produce black eyes, at the same time that the long adhesion, which is more general, more comprehensive, and projects beyond the first, *i. e.*, X M F Y, composed of plasmas of the total chromogene type N, will give the dark color to the fur.

The intervention of four determinants C, P (slight streakings because of achromic adhesions in C X^1 and Y B), N, M which is a special plasma.

2.—The sliding is continued. The useful adhesion of the chromogene determinant of the eyes is reduced to the line M F (Fig. 13).

The eyes will be black, for these organs are selectively charged with pigment, even when its proportion in the organism is limited. The fur will be streaked, with predominance of light borders, C X^1+Y B, achromic zones, being superior to X Y, the middle plane of fixation of the plasmas which are the vehicle of color, and this lightening of color will be proportional to the surfaces of adhesion with the adjacent achromic plasmas. It is the beginning of the mutation E. The intervention of five determinants C, P, N, M, E, of which two alone are concrete and material (N, M).

3.—The sliding is exaggerated until it definitely disunites the homologous chromogene zones (Fig. 14).

This gives total albinism, since the plasmas of the general color are brought to the position of Fig. 11, and the plasmas which are the vehicles of color are now united only to the achromic segments in C F and M B. There is no choroidal pigmentary manifestation, whence the red eyes of the albino. Here there is an intervention, or rather an unfolding of six determinants, namely: four determinants C, A, E, U, which are abstractions in any case, and finally, "for annulment", in the state of latent characters, of the two determinates M, N, which are plasmatic.

[TO BE CONTINUED]

Titanium in the Metallurgy of Iron

General Statement.—The effect of titanium on cast iron has been the subject of much discussion; not a great amount of data is available for the accurate solution of the question, but the probabilities are that the action of the metal has quite contradictory effects. This is presumed to raise from its varying action with the different metalloids. In an extensive paper in 1912 before the American Institute of Mining Engineers, Bradley Stoughton recorded data pertinent to the effect of titanium on the strength of cast iron. One particular point is to be noted from his findings, for the reason that it stands forth very prominently, and that is that titanium unquestionably reduces the chill. This should not be unexpected from what is known of the action of the metal—it being one of the strongest deoxidizers known, and it further has a high chemical affinity for both sulphur and nitrogen. The question logically arises: Why does titanium reduce chill? This is readily answered. The elements oxygen and sulphur (and nitrogen, probably) are productive of chill, and titanium, by removing them, consequently removes their chill action. This shows how the chill is modified and, further, why the strength of castings is lower. The titanium not only removes the sulphur but also the oxygen[1]. The effect of titanium in reducing chill in cast iron is overcome by the use of an increased proportion of manganese for purposes of restoration—and this is decidedly met with disapproval. It appears, on the whole, that not much benefit can arise from using titanium in the metallurgy of cast iron, but recently its use has been recommended by Doctor Moldenke the American foundry expert, as worthy of employment for the removal of nitrogen and oxygen where special cast irons are to be produced. Some metallurgists held for a long time that titanium rendered cast iron tough—probably, for one reason, because the well-known pig iron of Upper Styria contains a small percentage of the metal. However, steel made therefrom rarely showed any titanium content on analysis, because of the strong affinity of the element for oxygen.

How Titanium is Used in Iron Metallurgy.—In iron foundry practice, the usual method of employing titanium is to scatter a predetermined amount of a titanium alloy (ferro-titanium or ferro-carbon titanium, as the case may be) along the runner prior to tapping. Upon tapping the cupola, the titanium alloy is washed into the ladle with the stream of iron. As in steel practice, time should be allowed for the chemical reactions to complete themselves, so that the ladle should be held for about three minutes before pouring. Also, as in steel practice, care should be taken so that the slag be not allowed to come in contact with the alloy, as slag attacks the alloy with very great avidity, thus destroying its function. Iron may also be treated in the ladle by adding the titanium alloy to the ladle either before or during tapping. In small hand ladles it is an easy matter to stir the iron with a rod in order to thoroughly incorporate the alloy into the molten bath. For usual deoxidizing purposes, about two to four pounds of a 15 per cent titanium alloy per ton of iron will be requisite and sufficient.—From a paper on the Metallurgy of Titanium, by ROBERT J. ANDERSON, B.S., published in the *Journal of the Franklin Institute*.

[1] The effect of small amount of oxygen in cast iron is to increase its strength and resistance to shock. Oxygen to the amount of but 0.06 per cent. gives cast iron a tensile strength of 3500 pounds per square inch, as compared with 2500 pounds per square inch for otherwise similar non-oxygenated iron. Note Johnson, W. McA., "A Chemical Explanation of the Effect of Oxygen in Strengthening Cast Iron," *Bull. A. I. M. E.*, February, 1916, pp. 233-235.

Sugar Industry in India

THE question of encouraging the extension of sugar production in British territories is one that is now being considered by the Government. In fact sugar has become such an important commodity and so much prominence has been given to the striking fact of the British Empire's dependence upon foreign countries for supplies which might be produced within the empire, for instance beet sugar in the United Kingdom and cane sugar in other countries of the empire, that it is of importance to consider this question. Due attention is being given in India to the problem of increasing the output of sugar. India's production of cane sugar is about two and a half million tons a year, but this quantity is not sufficient for home consumption, and consequently some 600,000 tons are imported, mainly from Java and before the war from Mauritius. The average yield of sugar for the whole of India is about one and one-quarter tons per acre; in Java three tons per acre are obtained and about the same amount in Cuba, while in Hawaii five tons of sugar per acre are sometimes produced. To double the production of sugar in India per acre by improved methods of cane extraction would appear at first sight to be a simple matter and such a result would not only be of great profit to the native planter but would also provide a surplus for export to the world's markets. As a matter of fact the development of the sugar industry in India is a very large problem and full of difficulties, but it need not be supposed that the problem is insoluble or the difficulties insuperable. The Government of India is giving the subject constant attention, but it would appear that several years may elapse before substantial results are obtained. Among the numerous questions to be studied are the varieties of sugar cane suitable for particular localities, the relative values of the indigenous kinds compared with those introduced, and the soil treatment which will be the best for ensuring steady growth and a good yield of juice. The Government of the United Provinces is making a practical attempt to manufacture sugar on a European factory system, and this is an endeavor to advance a step beyond the careless and wasteful native methods of sugar extraction and at the same time avoiding the ideal of the large central factory system which cannot be attained at present. At Nawabganj in the Bareilly district a sugar factory has been established by state efforts, and a first report has been made by Messrs. Hulme and Sangchi on the results obtained. It seems that at first the idea of improving the native sugar-making methods appeared an easy one to realize, but the experience of a year or two has now convinced the authors that the mere introduction of crushing mills requiring greater animal power would prove no advantage to the planters, who in most cases have not capital enough for an outlay in an expensive plant. The greatest obstacles appear to be the jealousy of the sugar boilers who see in the improvements offered a menace to their old and absolete methods, as well as the obstinate resistance to innovations of any kind on the part of the native planter. These are serious difficulties, it must be admitted, but they are obstacles of the kind that have often had to be overcome in carrying out progressive methods and must surely be surmounted in the course of time. At any rate it is gratifying to note the interest that the Government is taking to increase the output of sugar in India, for this will not only improve the position of the native planter but also confer a benefit on the whole empire.—*London Chamber of Commerce Journal.*

Timber Use for Trench Building

Reliable estimates of the amount of timber which has gone into the shoring up of trenches and dugouts, into the miles and miles of trench sidewalks and corduroy roads, and into artillery and trench screens are not available, but the quantity, on the hundreds of miles of front, surely totals up to several hundreds of millions of feet. On the statement of a French colonel it is learned that as high as 30,000 trees were used daily by a single French army corps.

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